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FROZEN DOUGH PROCESS AND ITS IMPACT ON SOME BREAD QUALITY CHARACTERISTICS

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Abstract: The objective of this paper is to evaluate the technology of making bread from frozen dough, highlight the factors that influence the quality of bread from frozen dough and investigate some quality characteristics of bread obtained from frozen dough (mass, volume of bread, core porosity, acidity). Three samples were used for determination of bread frozen dough quality characteristics: bread made traditionally, from unfrozen dough, bread made from frozen dough for 24 hours and bread made from frozen dough for 48 hours, at the freezing temperature of –18°C. Dough freezing resulted in bread with modified quality characteristics compared to bread made from fresh and unfrozen dough. Thus, the weight loss of the bread made from the frozen dough, its smaller volume and also the low porosity and acidity are found.
Keywords: frozen dough, freezing, bread, quality

1. INTRODUCTION

The bakery industry is in a continuous evolution, rapidly adapting to the ever–increasing demands of consumers for fresh, healthy, safe and diversified products through the use of health–promoting raw materials and auxiliaries, complex textures and flavors. One of the biggest challenges of the bakery industry has always been to preserve those special qualities af aroma, taste and texture specific to the freshly baked product. The technology of obtaining bakery products by freezing allows producers to create and develop products to be able to meet consumer demands. In the past several decades, there has been an increasing interest for the freezing process of dough. In recent years, in our country too, a significant increase in the consumption and manufacture of bakery products from frozen dough has been observed due to the easy preparation process and the qualities that are increasingly close to those of traditional products. Thus, the freezing of bread dough was industrialized to reduce manufacturing times, increase production capacity, facilitate standardized product quality, expand the range of consumer products, extend the self–life, harmonize production with market requirements, (Rosell C. M. et al., 2007; Bahlina et al., 2019; Le–Bail A et al., 2012; Simurina D. Olivera, 2011). So, this technology of modern bakery is more profitable than traditional bakery technology in terms of the speed and costs of the production process. Prima țară care a debutat cu produsele de panificaţie congelate a fost Franța, (Ribotta PD. et al., 2001). They currently occupy an increasing share of the food market covering sectors such as supermarkets, restaurants, institutional and catering businesses, (Jinhee Yi, 2008). The European frozen bakery industry is the leader in the global bakery market, and according to statistics, Europe will continue to dominate the frozen bakery market, [38, 39].

With all benefits of dough freezing technology, the freezing and storage process can cause decline in the quality of frozen dough, such as weakening of the gluten network, responsible for retaining fermentation gases, reduction of yeast activity, which results in the gas formation in the dough after freezing (Olivera D.F. et al., 2009; Berglund P. et al., 1991; Ayati S.A. et al., 2017; Giannou V. et al., 2003; Wenhuang Luo et al., 2018). All of this affect the quality of final bakery product, such as loss of the specific volume of the bread, loss of moisture content, increase in the hardness of the crust, loss of flavour and deterioration of the product in general (Ribotta, P.D. et al., 2001). Therefore, in order to induce a minimal impact on the quality characteristics of final product, many research are made to both the technology applied and the ingredients used.

The methods of manufacturing bakery products from frozen dough are diversified, and they differ essentially by the moment of application of freezing, the temperature and speed of freezing, the temperature of the dough before freezing, the storage duration, the use of bakery improvers (antifreeze proteins, hydrocolloids, ice–nucleating agents), quality of basic raw materials (flour, yeast, water), thawing methods, conditions of proofing, (Neyreneuf O. et al. 1993; Autio, K. and Sinda, E. 1992;

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Bhattacharya, M. et al. 2003; Giannou, V. et al. 2003; Ribotta, P. D., et al., 2001; Simurina D. Olivera 2011; Selomulyo V.A. and Zhou W. 2007; Akbarian M. et al. 2016). So, the freezing processing factors who affect the quality of frozen dough and bread are the quality of basic raw materials, additives and processing parameters such as dough mixing time, freezing time, freezing rate, storage time, thawing rate. Advances in food technology have led to positive results such as increase yeast cell freeze tolerance and enhance dough functional properties during freezing and frozen storage, by the use of additives and the novel biotech ingredients and enzyme technology (Omedi, J.O. et al., 2019; Wang X. et al., 2018). Depending on the moment of application of freezing, the frozen dough can be divided into "ready to proof dough", which is obtained by immediately freezing after mixing or after a short proofing, and "ready to bake dough", obtained by freezing after mixing and complete proofing (Zhao Y. and Kweon, M., 2021; Rosell C.M. 2011).

In generally, frozen bread dough process is carried out up to a certain stage like traditional bread technology (without freezing dough), so involves mixing of raw materials, kneading, dividing, moulding, freezing the dough, storage of frozen dough, thawing, proofing and baking. Freezing dough pieces must be do immediately after moulding of dough pieces to low temperatures (below –18°C), to prevent excessive yeast activity. Then frozen dough pieces are storing at (–18°C) to (–23°C), studies showing that as the temperature of storage tends at (–30°C) or (–35°C) the bread has lower volume (Jinhee Yi and William L. Kerr, 2009; Guénaelle L. et al., 2010).

The literature showed that exists an indirect relationship between length of frozen storage and quality of the dough and the final product. The weakening of the gluten network takes place as the frozen storage period is longer and the storage temperature is higher, (Akbarian M. et al., 2015; Jinhee Yi and William L. Kerr, 2009). Another aspect which affects the structure of frozen dough is the rate of formation of ice crystals and dimensions of them (Wenjuan F. et al., 2020). The formation and irregular growth of ice crystals in the frozen dough is the main responsible factor of the loss of gluten structure and deterioration of starch granules, which reflected by the poor dough behaviour during baking and the loss of bread quality characteristics, respectively (Esselink, E. F. et al., 2003). The formation and irregular growth of ice crystals in the frozen dough reduces the vitality of microorganism and causes uneven distribution of pores (Guo Chen et al., 2012).

To maintain yeast viability, to improve frozen dough quality, rheological and structural of frozen dough properties and bread quality characteristics (higher specific volume, lower hardness, increase self–life) are use various additives such as hydrocolloids, antifreeze proteins, ice–nucleating agents, emulsifiers, enzyme preparations (Omedi, J.O. et al., 2019).

It is recommended that thawing of dough is made carried out slowly at room temperature (around 25°C) or in a proofer (at 30–40°C). When equilibrium is reached between the room temperature and that of the dough pieces, it will begin fermentation (Seonkyeong Yang et al., 2020).

Proofing of dough after thawing could be optional. For the dough piece to maintain its volume and structure, it is very important that the parameters of temperature (32–43°C), humidity (relative humidity of 70–75%) and time (80–100 minutes – longer than in case of no frozen dough) are properly adjusted. Baking of bread dough time and temperature are dependent on the type of oven and dimensions of dough pieces.

In the production of frozen dough, flour should be strong with high protein content (12–14%) to ensure sufficient dough strength and gas retention during proofing after thawing cycle, (Yadav DN et al., 2009; Simurina D. Olivera, 2011). The quality of flour is one of the most important factors that affects the quality of bread from frozen dough. The protein content is important, but more important is protein quality. The protein matrix of bread undergoes depolymerization during storage under freezing conditions (Ribotta P.D. et al., 2001), therefore flours with good quality proteins are needed, able to form strong gluten networks and to resist of pressure of fermentation gases.

Along with the flour, water plays a very important role in determining quality of frozen dough and bread from frozen dough. During the mixing of flour with water the gliadin and glutenin proteins are hydratases, swells and develop the gluten network and forms the structure of bread dough. The water hardness, the level of water addition and pH value influence the quality of frozen, dough and implicit

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the quality of bread from frozen dough. For a water pH value of 5–6, a hardness of 100 mg/L and water addition of 44–45 ml/100g all characteristics measured of bread from frozen dough (specific volume, aspect ratio, color, structure surface, internal structure, softness, elasticity) are improved (Bao Yuru and Wang Xianlun, 2011).

Level yeast in traditional baking is about 3% flour basis. In frozen dough process yeast should be added in a higher concentration, about 4–6% flour basis, to compensate the loss of activity during freezing and frozen storage of dough (Carr L.G and Tadini C.C, 2003; Salas–Mellado, M. M. and Chang, Y., 2003). Yeast characteristics also have an important role in keeping of yeast viability.

Salt level in traditional baking is about 1,5–2,0% based on the flour weight. In frozen dough is used a level of 1,8–2.25% salt based on flour weight. Salt is essential to enhance the flavour, increase dough stability, firmness and control yeast activity (Jinhee Yi, 2008; Simurina D. Olivera 2011).

Sugars are added in small proportions (3%) in frozen dough, because they influence the consistency of the dough and facilitate the start of the yeast activity in freezer (Bordei D. et al., 2000).

Bakery products quality from frozen dough can be improved by add different ingredients and by controlling the freezing process and the storage conditions (Le–Bail, A. et al., 2010; Carboni, A.D. et al., 2022; Kondakci, T. et al., 2015).

The aim of this paper was to evaluate the technology of making bread from frozen dough, highlight the factors that influence the quality of bread from frozen dough and investigate some quality characteristics of immediately baked bread and bread obtained from frozen dough (mass, volume of bread, core porosity, acidity).

2. MATERIALS AND METHODS

The experimental research was carried out at the Faculty of Biotechnical Systems Engineering, Politehnica University of Bucharest. A commercial bread wheat flour with moisture content of 13.7%, ash content of 0.45%, protein of 10 %, Farinograph water absorption of 56 %, dough stability 3 min, degree of softening of 5.7 U.B. (Brabender Unit), was used. Formulation of bread dough was comprised of 450 g white wheat flour, 280 g water, 8 g salt, 7 g dried yeast, 8.5 g sugar and 12 g sunflower oil. Three samples were used for determination of bread quality characteristics and were named: B1 – control sample, refers to bread made from nonfrozen dough, B2 – bread made from 24 h frozen storage dough, B3 – bread made from 48 h frozen storage dough. Dough samples for each bread were prepared in the same conditions using the Tefal breadmaker machine. Breadmaker machine was use for mixing and proofing, for a total time of 1 hour and 9 minutes. After that, the control dough samples (B1) were rested, divided, shaped and baked in an electric oven with convection, FM RXL–424 model and the frozen dough samples (B2, B3) were divided, shaped and packed in double polyethylene bags and transferred to a storage freezer at – 18^{o}C (the most common and used storage temperature for bakery products) for 24 and 48 hours. The frozen dough samples were thawing at 20^{o}C for 12 hours, before being baked in the electric oven. Dough pieces were baked at 180^{o}C for 45 min. After baking and complete cooling of the breads, their mass was determined with an analytical balance. After 3 hours from removing from the oven, their volume was measured by rapeseed displacement, core porosity, elasticity, and acidity were determinate according to the Romanian Standards SR 91–2007. The methods are described in paper (Munteanu G.M. et al., 2019). Each measurement was performed in duplicate.

3. RESULTS

The results of bread quality characteristics produced from nonfrozen dough and frozen dough are shown in Table 1 and Figure 1.

A decrease in the quality characteristics of the bread samples obtained from frozen dough is observed in comparison with the bread sample obtained from non–frozen dough. Frozen dough changed the bread quality characteristics.

The weight of bread made from nonfrozen dough, and the B2 and B3 were of 661.2 g, 590.8 g and 586.2g, respectively. A slight weight loss is observed as the dough frozen storage period increased, suggesting a dehydration of crumb.

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Table 1. Bread characteristics

Bread characteristics	Samples		
	B1	B2	B3
Bread weight, [g]	661.2	590.8	586.2
Bread high, [mm]	94	80	66
Bread volume, [cm^3]	208.5	142.6	118.5
Bread porosity, [%]	80.3	68.6	58.5
Bread core elasticity, [%]	96.67	98.33	99.67
Moisture content, [%]	43.29	43.27	34.47
Bread acidity, [gr.acid.]	2.2	1.8	1.6

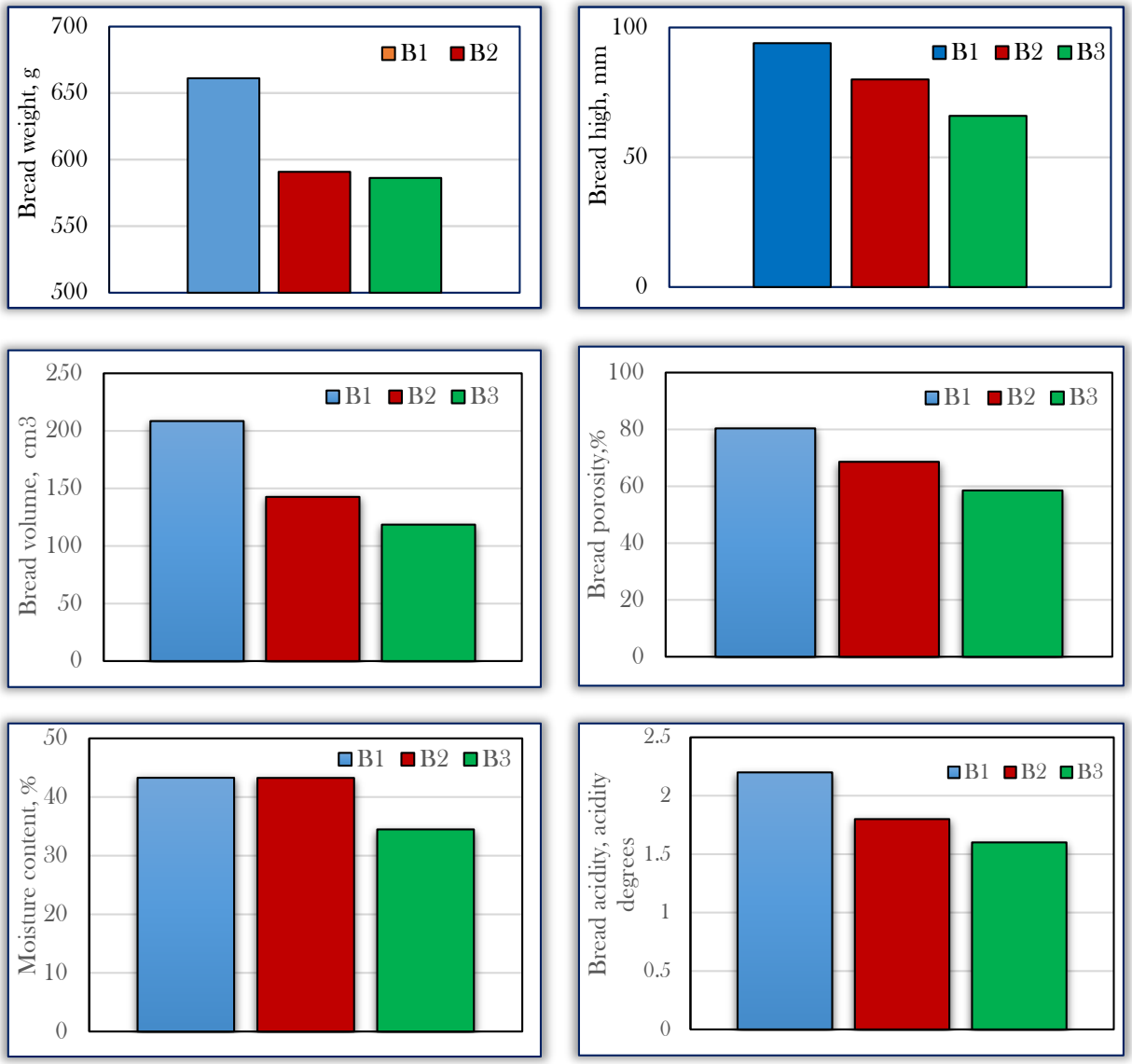

Figure 1 – Effect of frozen dough on the basic quality characteristics of bread (B1 – control sample – bread made from nonfrozen dough, B2 – bread made from 24 h frozen storage dough, B3 – bread made from 48 h frozen storage dough).

The bread volume is a quality parameter as indicates of the gas retention ability of the dough and gas production, which is linked to yeast activity. Based on results it was observed that the volume decreased as the dough frozen storage period increased. These may be explained by the fact that frozen storage contributes to weakening of the gluten network, causes starch damages, which leads to loss of dough strength and diminished yeast activity, respectively (Ribotta, P.D. et al., 2001). The formation of ice crystals in the freezing process causes damages to the gluten network, disrupting its integrity, which induces the loss of gass retention capacity, or a reduction in the maximum resistance to expansion of the dough. (Ayati S.A. et al., 2017).

As can be seen from Figure 2, the crumb porosity is more evident for breads from frozen dough (B2 and B3 samples) in comparison with bread from nonfrozen dough (B1). Also, it has been observed that

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breads from B2 and B3 samples showed an increase in sizes crumb gas pores than bread of B1 sample and an irregular distribution of these. Crumb pores are form by the gas cells. The formation of this large gas pores in the crumb structure of bread from frozen dough is described in detail in the papers (Guo Chen et al., 2012). The way of development of the porous crumb structure depends on many factors of which the main ones are raw materials, wheat flour characteristics, yeast activity and processing conditions (Reynold R. et al., 2012; Gonzales–Barron Ursula and Francis Butler, 2008; Carboni, A.D. et al., 2022; ZHANG Lin et al., 2022).

Bread crumb structure, aspect, texture and another sensory characteristic play an important role in estimating the bread quality because they are the determining factors by which the consumers judges the final product. So, although the bread from frozen dough has lower mass, volume, height, porosity, the attention should also be paid to the sensory characteristics, such as the freshly baked smell, the taste, the condition and appearances of the crust, the colour, because these are the first criteria by which the consumer choose the product.

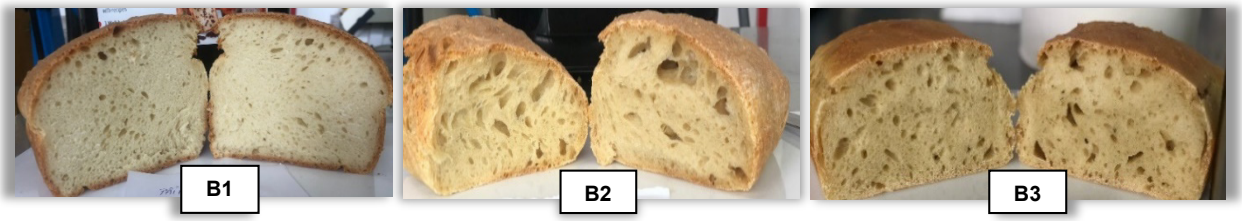

Figure 2 – Crumb appearance of breads (B1 – control sample – bread made from nonfrozen dough, B2 – bread made from 24 h frozen storage dough, B3 – bread made from 48 h frozen storage dough).

The frozen storage temperature of the dough was –18° C, for a not very long time, that of 24 hours and 48 hours. That's why the effects were not so pronounced, as shown by other researchers who studied the effect of dough storage at temperatures lower than –20° C for periods of time from several weeks to several months. They obtained significant differences between the quality characteristics of bread made from non–frozen dough and those of bread made from frozen dough, (Jinhee Yi 2008).

The odour of the freshly baked breads from sample B1, as well as those from samples B2 and B3, was pronounced, pleasant, characteristics of well–baked bread, with the difference that the breads from frozen dough had a stronger freshly baked odour with a deeper smell of" fermented product" than bread from sample B1. The same was current regarding the taste, which felt more pronounced" fermented product" in the case of the frozen dough bread samples. In term of colour, bread from samples B2 and B3 had a slightly brown crust with a dark yellow core, unlike the unfrozen dough bread, which had a yellowish–golden crust and a dark core specific to white bread.

In this paper the bread dough was prepared from only main raw materials (flour, water, salt, dried yeast), but in much research have shown that the quality of bread or another bakery products can be improved by use of various additives. Thus, in the paper (Asghar A. et al., 2012) it was shown that by adding polyols (sorbitol and mannitol) at the level of 2% on flour weight basis, the quality of frozen pizza dough improved; in paper (Ribotta P.D. et al., 2001) adding diacetyl–tartaric acid ester of monoglycerides, gluten and guar gum in base formulation of frozen dough produced breads of improved volume and open crumb structure; the frozen dough with incorporated different fibres positively contribute to bread quality (Filipovic J. et al., 2010); in paper (Sharadanant R. and Khan K, 2006) have been shown that the hydrophilic gums improve the self–life stability of frozen dough during long periods of frozen storage; mixtures of milk proteins and gums proved enhance the quality of bread and retard the deterioration of frozen dough (Shon J. et al., 2009).

4. CONCLUSIONS

That quality characteristics presented in paper are important and can be considered as key parameters for the performance of both conventional and frozen bakery products. The quality of bread made from frozen dough is diminished by changes that occur during the freezing process and the frozen storage. The main causes of this process are dough weakening and yeast damage.

The general conclusion which can be derived from these results is that the freezing of dough and storage under freezing conditions (–18° C), even for a short time, leads to diminish the quality

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characteristics of bread. Thus, the weight loss of the bread made from the frozen dough, its smaller volume and also the low porosity and acidity are found. It is very important that to obtain the quality expected of bread made from frozen dough both the role of each ingredients, the interactions between ingredients and the technology used should be studied.

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