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Correlations between the quality parameters and the technological parameters of bread processing, important for product marketing

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Abstract

The present research aimed to assess interdependencies between certain technological parameters of the manufacturing process of bread (the amount of added water, the kneading time, the temperature of dough, the proofing time, the bench proofing time) and some quality parameters of the finished product, significant in its marketing (volume, porosity, elasticity, fractal dimension). In this respect, we analyzed 36 samples of bread made from Romanian flour after a standard recipe. The results showed that the volume of the finished products was positively correlated with the intensive kneading time and the proofing time, and negatively with the amount of added water. Porosity of bread increased significantly with the bench proofing time. Elasticity increased significantly as the temperature of dough and the bench proofing time increased and also increased significantly with increasing of added water amount. The main technological parameters that influenced the fractal dimension of the pores in the bread crumb were: the amount of added water (r = 0.57***) and the intensive kneading time (r = -0.50***).

Keywords: bread processing, quality parameters, technological parameters, image analysis

Introduction

Bread is always present in the daily diet, being one of the main products of Romanian food industry. The annual average consumption of bread per capita, estimated at 97 kg / capita [1], exceeds the European average. About 55% of the Romanian households consume unpacked bread, acquired mainly from small supermarkets and bakeries [2]. Most Romanian people prefer white bread and loaf. The main criteria which determine the acquisition of unpacked bread are quality and aspect, according to most studies conducted in recent years. Other criteria such as: price, shop close to home and the type of flour can be considered secondary [3].

The assessment of bread aspect involves a complex analysis, that can not be limited to a few quality parameters. Aspect of bread is generated by some factors such as: quality of ingredients, recipe, the applied technology, control of technological process. However, certain parameters such as bread volume, porosity and crumb represent the main problems associated with the aspect and quality of bread.

Taking into consideration the importance of bread aspect in the consumer's purchase decision, we considered as necessary to achieve a study in order to correlate the main quality parameters related to the aspect of bread (volume, porosity, elasticity, etc.) with some technological factors (amount of added water, intensive kneading time, dough temperature, bench proofing time and proofing time, etc). Also, taking into consideration the current interest in the scientific community to implement new methods for evaluating the quality of products, we intend to analyze the relevance of bread pore fractal dimension in the context of the data we gathered.

Materials and methods

We made baking samples for 36 Romanian flours from wheat crops of the years 2011 to 2012 according to the recipe and to the parameters of baking process presented in Table 1. The experiment was conducted in order to approach as much as possible of the technological realities in a bread factory: the quantities of flour, salt and yeast were the same for all baking samples. The amount of added water, the intensive kneading time, the bench proofing time and the proofing time have been adjusted according to the technological requirements, in order to obtain an optimum volume of the finished product.

Table 1

Technological parameters and the recipe for baking samples

Specification	Value
Wheat flour	1 kg
Salt	13 g
Yeast	23 g
Water (Wa)	Variable, depending on the technological requirements of flour: 550 – 607 ml
Slow kneading time (V1)	3 min
Intensive kneading time (V2)	Variable, approx. 5 – 8 min, depending on the technological requirements of flour
Bench proofing time BPT (at room temperature)	Variable, approx. 20 – 25 min, depending on the technological requirements of flour
Proofing time PT (35^0C, 78 % humidity)	Variable, approx. 43 – 54 min, depending on the technological requirements of flour
Baking	220^0C, for 20 min

At the end of the kneading operation we measured dough temperature using an electronic thermometer. The dough was divided into portions of 350g each, in order to allow obtaining of a final product with the weight of 300g.

The equipment we used for making the baking samples included an intensive mixer with spiral and having the tank capacity of 30 kg, a dough moulder (for long format), a baking proofer with controlled temperature and humidity and an electric baking oven.

For each of the 36 samples we selected two loaves for which we measured, at 2 hours after baking, the following quality parameters:

- Volume (V, cm^3/100g) according to SR 91:2007, using a Fornet apparatus;
- Porosity (P, %) according to SR 91:2007, using the weighing method;
- Elasticity (E, %) according to SR 91:2007 [4].

The values used in the study represent the arithmetical average of the determinations carried out for the two loaves of bread, selected at each baking sample. Note that Volume, Porosity and Elasticity are used in marketing of bread and bakery products, since they influence decisively consumers' option to buy.

Slices of bread samples were scanned at a resolution of 200 dpi using a commercial scanner, for obtaining digital images (Figure 1). Digital images were analyzed using a specialized software Image J, developed by the National Institutes of Health (U.S.), in order to determine the fractal dimension (df) of the form of pores of the bread crumb [5]. Fractal dimension (Hausdorff dimension) measures the degree of complexity of the shape of a geometric structure, its value being higher as the structure is more complex.

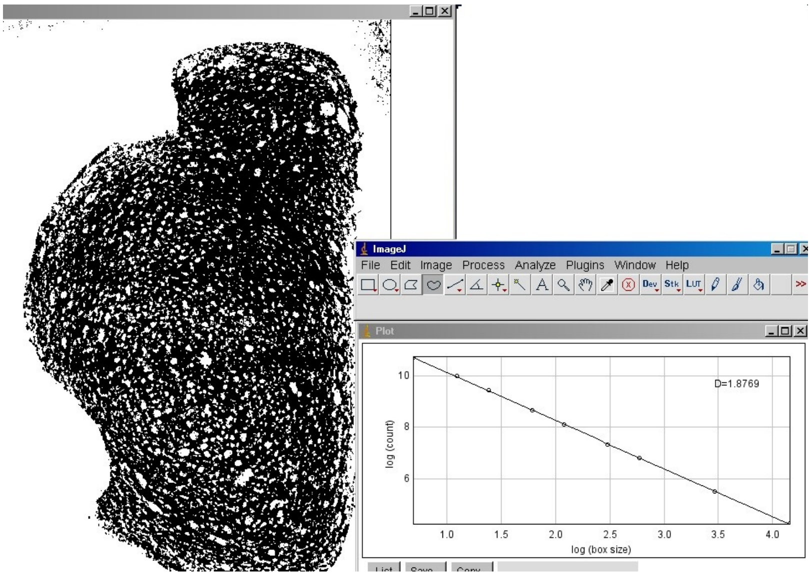


Figure 1. The image of a slice of bread (software Image J)

The computer program quantified the fractal dimension of bread pores by the box-counting method, using the binary forms of the original images of bread slices. Fractal dimension can be variable, depending on the nature of the object measured (0 for point, 1 for line, 2 for plane, 3 for sphere etc.) [6, 7].

Results and discussions

The values of estimates of variability for the main technological and quality parameters of the 36 samples of bread are presented in Table 2.

Table 2

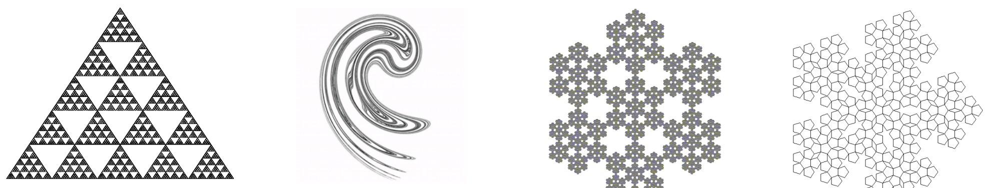
Estimates of variability for the main technological and quality parameters of bread

Specifications	$X \pm s_x$	CV (%)
Water added (Wa, %)	58.342 ± 1.523	2.610
Dough temperature (DT, ^{0}C)	29.267 ± 0.417	1.423
Intensive kneading time (V2, min)	5.389 ± 0.761	**14.121**
Bench proofing time (BPT, min)	22.639 ± 2.514	**11.104**
Proofing time (PT, min)	47.889 ± 2.826	5.901
Bread volume (V, cm^3/100 g)	508.361 ± 36.751	7.223
Porosity (P, %)	86.081 ± 2.943	3.419
Elasticity (E, %)	96.667 ± 1.233	1.276
Fractal dimension (df)	1.773 ± 0.083	4.681

In table 2 we notice that baking samples were relatively homogeneous, regarding the technological parameters. Bigger variations were recorded regarding the intensive kneading time (14.121%) and bench proofing time (11.104%). Homogeneity is reflected in the low level of the quality parameters' variability of bread. Practically, the quality parameter with the highest variability was the Volume of bread (7.223%), while the Elasticity parameter recorded the lowest variability (1.276%). As for the fractal dimension, it had a low variability, but still higher than the variability associated to Elasticity and Porosity parameters.

The mean values of Volume, Elasticity and Porosity, describe a high quality bread, elastic and having normal porosity.

The fractal dimension of the shape of bread pores varied from 1.69 to 1.86. This range of values covers a multitude of fractal patterns, described in literature, from Pascal's triangle modulo 5 (df = 1.68) and Ikeda map attractor (df = 1.7), until the Pentaflake model (df = 1.86). The mean value of fractal dimension, identified in the analyzed samples (1.77) is similar to Hexaflake model (df = 1.77). Figure 2 presents some models of fractals, with Hausdorff dimensions similar to those identified in the case of the shape of bread pores [8].



Pascal triangle modulo 5 | Ikeda map atractor | Hexaflake | Pentaflake

Figure 2. Models of fractals

How technological parameters influenced the quality parameters of bread is shown by the table containing the correlations between all these parameters (Table 3).

Table 3

Correlations between the technological parameters and quality parameters of bread

Variable	Wa	DT	V2	BPT	PT	V	P	df	E
Wa	1.00								
DT	-0.26	1.00							
V2	-0.24	-0.04	1.00						
BPT	0.07	**-0.33***	-0.18	1.00					
PT	-0.17	0.02	**0.48****	**-0.69*****	1.00				
V	-0.32	0.17	**0.40***	-0.07	**0.47****	1.00			
P	-0.19	-0.11	0.03	**0.34***	-0.07	**0.35***	1.00		
df	**0.57*****	0.06	**-0.50****	-0.15	-0.06	**-0.43****	-0.24	1.00	
E	**0.42****	-0.28	0.14	0.24	-0.18	-0.11	-0.20	0.05	1.00

*p<0.05; **p<0.01; ***p<0.001

In table 3 we notice that the Volume of bread increased significantly with increase of intensive kneading time (r = 0.40*) and distinctly significant with increasing of the proofing time (r = 0.47**). This is due on one hand to improving the dough structure with the increase of kneading time, and also to increasing the amount of gas fermentation with increasing of proofing time (r=0.47**).

The Porosity of bread increased significantly with increasing of the bench proofing time time (r = 0.34*). At this stage dough relaxation occurs, as a result of the internal tensions to which it has been subjected during kneading, splitting and shaping, and the dough begins to accumulate fermentation gases.

Elasticity of bread increased distinctly significant as the amount of added water in recipes increased (r = 0.42**). This is probably due to the formation of a more compact structure of bread crumb, in terms of using larger amounts of water. As known, water provides optimal hydration kneading of proteins during kneading, as well as starch gelatinization.

Note that as the amount of water in recipes has increased, the degree of irregularity of pores expressed by fractal dimension has increased very significantly (r = 0.57***). This is most likely due to the fact that in a softer dough, the ability of gluten films to preserve the form of the pores, in which the gas bubbles are embedded, is lower (they are more extensive, but less resistant to gas pressure in baking).

It is noteworthy however that fractal dimension of pores decreased distinctly significant, as the intensive kneading time of dough increased (r = - 0.50**). Intensive kneading optimized the distribution of protein films around starch granules and provided a better mixing of all the components of dough. This fact is reflected in a more regular structure of the bread crumb. However , there is a negative distinctly significant correlation between the volume of bread and fractal dimension, which means that the bread with a bigger volume showed a more regular shape of the pores (r = - 0.43**).

Conclusions

In conclusion, the results of our experiments show that the main quality parameters that can be associated with the aspect of bread and have an impact on the product marketing, are significantly affected by the technological parameters and the recipe of bread.

So:

- The Volume of finished goods decreased according to the amount of added water, but increased with the increasing of the intensive kneading time and of the proofing time;
- The Porosity of bread increased significantly with the bench proofing time;
- Elasticity increased significantly as the temperature of dough and the bench proofing time increased and also increased significantly with increasing of added water amount;

- The fractal dimension of the pores in the bread crumb increased with increasing of the amount of added water, but decreased with prolongation of intensive kneading time.

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