Studii şi Cercetări Ştiinţifice
Chimie şi Inginerie Chimică, Biotehnologii, Industrie Alimentară

2019, **20** (4), pp. 575 – 584

Scientific Study & Research
Chemistry & Chemical Engineering, Biotechnology, Food Industry

ISSN 1582-540X

ORIGINAL RESEARCH PAPER

DYNAMICS OF FERMENTATION PROCESS OF BREAD DOUGH PREPARED WITH DIFFERENT TYPES OF YEAST

Gabriela-Mariana Munteanu, Gheorghe Voicu*, Mariana Ferdeş, Elena-Mădălina Ştefan, Gabriel-Alexandru Constantin, Paula Tudor

[1]*University Politehnica Bucharest, Faculty of Biotechnical Systems Engineering, Splaiul Independentei 313, Bucharest, Romania*

*Corresponding author: ghvoicu_2005@yahoo.com

Received: July, 19, 2019
Accepted: November, 14, 2019

Abstract: The dough fermentation process is a major step for obtaining good quality bread because the yeast cells, which release CO_2, have a major influence on dough rheology, volume, texture and taste of final bread product. The fermentation speed of the dough is strongly influenced by the fermentative performance of the yeast and dough fermentation conditions.
Therefore, this paper presents the dynamics of the yeast fermentation process prepared with three commercial types of dry yeast, namely: Pakmaya, Dr. Oetker, Rapunzel.
It has been experimentally found that besides the dynamics of the fermentation process, there are also changes in the physico-chemical properties of the dough, but also of the bread obtained from the three types of dough.

Keywords: *wheat flour dough, yeast, fermentation process, dough properties*

INTRODUCTION

Yeast is a primary agent who consumes the sugars present in the dough, and which by its activity produces the alcoholic fermentation that results CO_2 [1 – 3]. Carbon dioxide (CO_2) it aims to transform dense mass of dough in porous dough with specific volume and flavor. During fermentation, no new bubbles are created, but only the volume of bubbles already in the dough can be increased due to the production of CO_2, thereby increasing the dough volume [3, 4]. It results, thus, that kneading is especially important in terms of the number of pores created at this stage. To increase the dough volume, it must be taken into account that the fermentation temperature is between 25-30 °C, there is a small amount of sugar and starch in the dough composition, and the water used for kneading is not too cold or too hot. The rate of fermentation of sugars fermentable is closely related to the possibility of glucose supply and the ability to hydrolyze maltose and diglucides formed by the activity of flour amylolytic enzymes on starch [5]. The amount of yeast required to increase the bread dough volume depends on the type of yeast used, by temperature of the dough and the duration of the fermentation time [2]. If the fermentation process is delayed, the acid produced by the oxidation of alcohol leads to the production of sour taste products [1, 6].

Yeast is a very small plant organism which can be seen only on a microscope, and the most used in the bakery industry belongs to the species *Saccharomyces cerevisiae* and is marketed in multiple forms: fresh yeast (compressed), instant yeast, active yeast and liquid yeast [2, 3, 7].

In this paper, the fermentation capacity of three commercial types of yeast in the dry state is monitored (Figure 2): active dry baker’s yeast sold under the Pakmaya trade name, produced by Rompak SRL, Turkey, active yeast under the trade name Dr. Oetker , produced by Dr. August Oetker, Germany and active organic yeast that is based on 100 % grain organic farming and is sold under the trade name Rapunzel, produced by Rapunzel Naturkost, Germany, but also its influence and fermentation time on the physico-chemical properties of bread.

The evaluation of physico-chemical properties of bread contributes to the characterization of quality and the initiation of some directions to improve it and can be done through various methods of laboratory determination of volume, the porosity and elasticity of the core [8].

The volume of bread is an important visual feature and provides a quantitative measure of baking performance and the dough's ability to retain the gas, and he reaches the desired values, for fermented products, only if a favorable environment for the growth of yeast and gas generation is ensured [9].

Porosity is given by the total volume of the existing pores in a core volume and is an important quality index, because it depends on the degree of assimilation and it also indicates the way the technological process was carried out. If a product has a poorly developed porosity and pore thick walls, then the dough was insufficiently fermented or baked [8].

The elasticity of the bread core is due to the quantity and quality of the gluten present in the flour and freshness of the product, and is the property of the core to return to its original form, after the pressing force has slowed down.

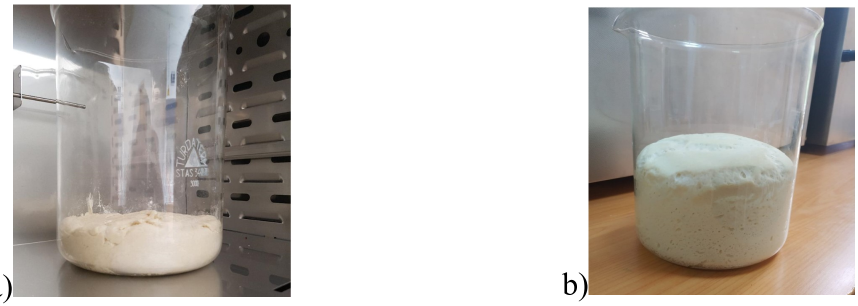
MATERIALS AND METHODS

The experimental researches took place within the Faculty of Biotechnical Systems Engineering at the Polytechnic University of Bucharest. For conducting experiments, were prepared using the Pain Plaisir PF220 bread making machine, Tefal brand (Figure 1), three types of dough with three different commercial types of dry yeast. Viability is defined as a percentage of live cells in a whole population. The viability of dried yeast was analyzed using a stain-based method (with methylene blue), that provide rapid and objective results. Cell viability is required for the estimation of the physiological state of the yeast after drying, which has an important influence on the dough growth.
The mechanism of action of the dye depends on the properties of the cell membrane. Living cells are able to reduce the dye such as methylene blue, and remain colorless, whereas dead cells are unable to do it and therefore are stained blue. This method enables observation of a single yeast cell, making distinction between alive or dead cells and measuring the percentage of these two categories of cells in the whole population [10].
The doughs were prepared from 325 grams of wheat flour F650 purchased from the Moara Greci in Ilfov County, Romania, 210 mL of commercial water, 9.3 mL of oil, 3.2 g, salt, 4.65 g yeast (Pakmaya/ Dr. Oetker/ Rapunzel), 9 g sugar. The recipe and the order of placement of the ingredients in the cuvette were those indicated by the manufacturer of the bread maker. After kneading all the ingredients using program 5 and 108 rpm at the kneading arm, for 15 minutes, doughs were placed in Berzelius glasses with a volume of 3000 mL and held for 90 minutes in the Memmert thermostat at the temperature 30 °C.

Figure 1. *Bread maker Pain Plaisir PF220*
1 - cover; 2 - control panel; 3 - kneading bowl; 4 - kneading arm [11]

Figure 2. *Dried yeast product*

To evaluate the dynamics of the fermentation process of the three types of dough during the thermostatic period, the dough height values in the pot were recorded at 10 minutes. The 0 minute moment is the moment of introducing the Berzelius into the thermostat (Figure 3).



a) b)

Figure 3. *Aspects during the determination of the dynamics of the fermentation process*

a) the initial height of the dough (minute 0); b) final dough height (minute 90)

Besides the study of the dynamics of the fermentation process, analyzes were also made on the qualitative indices for the breads obtained from the three types of dough. To highlight the influence of fermentation time on the physico-chemical properties of bread obtained from the three types of dough, breads of the same type of dough were made, only that kneading, fermentation and baking took place in an uninterrupted process directly into the bread maker, respecting the same parameters set for obtaining the doughs and breads mentioned above.

Thus, doughs prepared after the recipe mentioned and after thermostat 90 minutes at 30 °C were returned into the bread maker and baked for 20 minutes.

It has been found that qualitative grades of bread are strongly influenced by the amount of carbon dioxide formed in the dough and its ability to retain the gas, and for their determination several analyzes and measurements were made on the bread and on its core.

After baking and cooling the 6 samples of bread (not earlier than 2 hours and no later than 20 hours after removal from the oven), these were weighed and then cut to extract a core cylinder with the height (H) of 6 cm and diameter (D) of 3 cm. With the obtained values the volume of the core was calculated with the relation (1) and its specific mass with the relation (2):

$$V = \frac{\pi \cdot D^2}{4} H \ [\text{cm}^3] \quad (1)$$

where: V - is the volume of the core [cm^3]; D - cylinder diameter [cm]; H- the height of the cylinder [cm].

$$\rho = \frac{m}{V} \ [\text{g}\cdot\text{cm}^{-3}] \quad (2)$$

where: ρ - is the bulk density of the core [$\text{g}\cdot\text{cm}^{-3}$]; m - the mass of the core [g]; V - core volume [cm^3].

The core cylinder was obtained by means of a cylindrical metal punch in the middle of the bread, this being weighed separately. With the obtained values, the porosity (P) of the core was determined with relation (3) [12]:

$$P = \frac{V - \frac{m}{\rho}}{V} 100 \ [\% \text{ vol.}] \quad (3)$$

where: V - represents the volume of the core cylinder, [cm^3]; m - the mass of the core sample, [g]; ρ - core density, [$\text{g}\cdot\text{cm}^{-3}$], (for whit e bread $\rho = 1.31 \ \text{g}\cdot\text{cm}^{-3}$).

In order to determine core elasticity, a HOUNSFIELD H1KS mechanical test apparatus was used, which was equipped with a press fitting and a force cell of 10 N. After placing the core cylinder on the fixed crosspiece of the mechanical test apparatus the movable traverse was lowered (with speed 50 mm·minute^{-1}) and the core cylinder pressed until ½ of his height, keeping it for 1 minute. After lifting the compression plate, the sample was left free for 1 minute and then the height again measured (Figure 4). The elasticity of the core (E) was calculated using the relation (4) [12]:

$$E = \frac{B}{A} 100 \ [\%] \qquad (4)$$

where: *A* represents the height of the core sample before pressing, [mm]; *B* represents the height of the core sample after pressing and returning, [mm].

Figure 4. *Images of experiments*

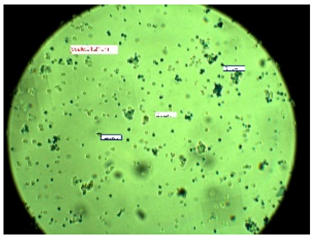
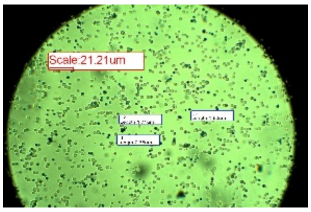
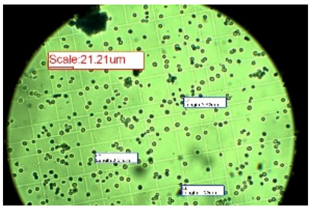
It should be noted that two rows of experiments were performed, under the same conditions, and the results presented below relate to their average.

RESULTS AND DISCUSSION

The results obtained have shown that the development of the dough is strongly dependent on the type of yeast used and the fermentation time.

Dry yeast is obtained from the species *Saccharomyces cerevisiae*, considered a superior fermentation yeast, adapted to produce fermentation of dough sugars. It has the ability to rapidly ferment glucose, fructose and sucrose and, after an adaptation phase, maltose, the main disaccharide formed in dough under the action of amylase from flours. The fermentation process is strongly influenced by the physiological state of the yeast cell. For this reason the cell viability of the three dried yeast preparations was analyzed and the results are presented in the Table 1.

Table 1. *Viability of the three dried yeast preparations*

Dried yeast product	**Viability, [%]**	**Microscopic image**
Pakmaya	78	
Dr. Oetker	83	
Rapunzel	72	

Experimental results for the dynamics of the fermentation process for the three types of dough during the period in which they were placed in the thermostat have been processed using MS Office Excel and are presented in Table 2, with this data the curves of the Figure 5 being plotted.

Table 2. *Values of the dough height*

Dough with yeast	**Dr. Oetker**		**Pakmaya**		**Rapunzel**	
Time [min]	Height [mm]	Percentage increase of H [%]	Height [mm]	Percentage increase of H [%]	Height [mm]	Percentage increase of H [%]
0	28	0	38	0	32	0
10	37	32.14	53	39.47	32	0
20	61	117.86	65	71.05	32	0
30	82	192.86	80	110.53	35	9.38
40	102	264.29	100	163.16	45	40.63
50	112	300.00	109	186.84	49	53.13
60	118	321.43	123	223.68	54	68.75
70	115	310.74	124	226.32	60	87.50
80	115	310.74	110	189.47	67	109.38
90	113	310.74	110	189.47	72	125.00

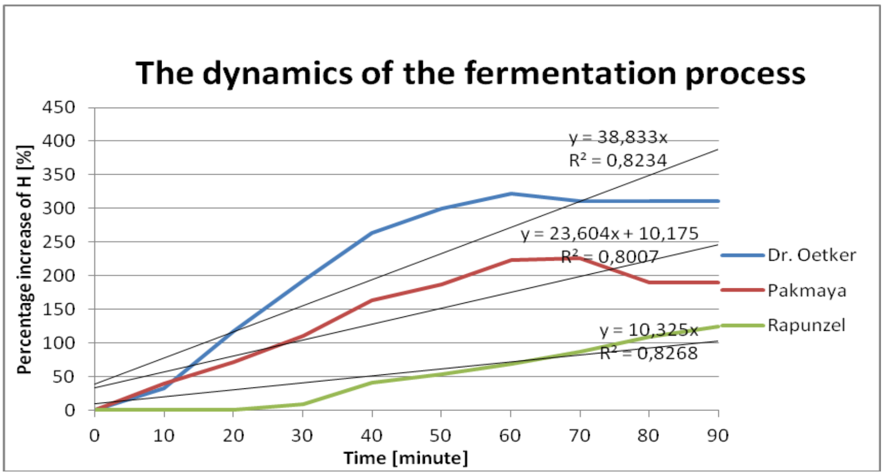


Figure 5. *The dynamics of the fermentation process*

It has been found that dough containing Rapunzel yeast records the lowest percentage of the height of the dough throughout the entire fermentation period, while dough prepared with yeast Dr. Oetker and Pakmaya records increases of H to 321.43 %, respective 226.32 % versus the initial height of the dough. The low percentage for the dough containing Rapunzel yeast may be due to delayed fermentation time. Both the data in Table 1 and the graph in Figure 5 shows that this type of dough has kept its initial height about 20 minutes (about 32 mm), and only then values of increase in height were recorded up to 90 minutes, there is no moment of decline during this time.

The highest increase in height was recorded by dough prepared with yeast Dr. Oetker, even within the first 20 minutes of being inserted into the thermostat, what it looks like during this time a larger quantity CO_2 was issued, which has led to an increase in the volume of bubbles existing in the dough. This type of dough kept a rising trend up to about minute 60, at which time the highest height of the dough was recorded, i.e. an increase of about 321.43 % compared to other types of dough.

For dough prepared with yeast Dr. Oetker there is a decrease in the height of the dough in the last part of the thermostation process from about 321.4 % to 310.7 %, value that kept constant from minute 70 to minute 90, the same thong is also found for dough prepared with Pakmaya yeast, of which height decrease from about 226.30 % to 189.50 % for the last 10 minutes of thermostat.

Can make such a remark and for the Rapunzel yeast preparation whose fermentation started somewhat later, and which in the 90th minute is increasing its height.

In view of the above, the final fermentation should be completed after about 60 minutes for the dough with yeast Dr. Oetker, after about 70 minutes for the dough with yeast Pakmaya, dough with Rapunzel yeast having a longer fermentation period.

For the data presented in Table 2 and Figure 5 regression analysis was performed to estimate the law of the height of the dough and the correlation between them.

It is thus found that for a law of linear variation the correlation coefficient R^2 has values of about 0.823 for dough with yeast Dr. Oetker, 0.800 for dough with yeast Pakmaya and 0.954 for dough with yeast Rapunzel. If a second degree polynomial variation law is used, values of the correlation coefficient R^2 is changing accordingly: 0.894 for dough with yeast Dr. Oetker, 0.962 for dough with yeast Pakmaya, 0.982 for dough with yeast Rapunzel.

Table 3. *Qualitative indices of finished products*

Dough with yeast	**Dr. Oetker**		**Pakmaya**		**Rapunzel**	
Proofing time [minutes]	**20**	**90**	**20**	**90**	**20**	**90**
Weight of bread [g]	472.3	465.6	455.6	463.9	481.5	480
Specific mass of the crumb [$g \cdot cm^{-3}$]	0.344	0.406	0.342	0.349	0.483	0.434
Porosity [% vol]	73.71	69.04	73.90	73.38	60.76	66.89
Elasticity [%]	93.30	90.00	88.33	66.66	88.30	91.66
Loss of baking [%]	15.83	17.02	18.81	17.33	14.19	14.46

Table 3 shows the quality indices of breads obtained from doughs prepared with the three types of yeast, where the time of 20 minutes is the rising time of the program 5 at bread maker machine, and the time of 90 minutes is the rising time in thermostat. It was not more than 10 seconds since the dough was removed from the thermostat until it was put in the machine and the baking program started.

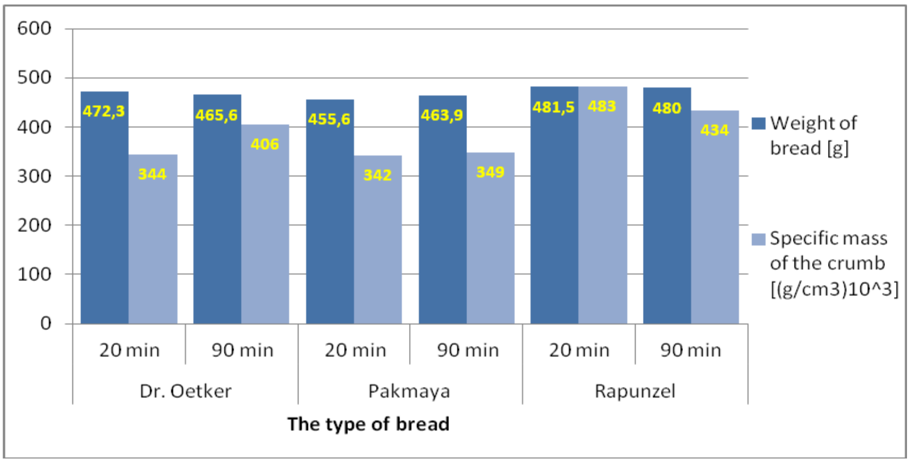


Figure 6. *Variation of bread weight and specific volume of the core*

Analyzing the values of the bread mass (in general) and the volumetric mass of the core from Table 3 and Figure 6, are found to be differences that can be attributed to the different formation of the shell of the products.

Also, due to the different fermentation mode there are major differences from the bread obtained for a 20 minute fermentation time to that obtained after 90 minute fermentation, even for the same type of dough. It is noted, also, the bread prepared with yeast Rapunzel has the densest core, while the soft core (porous) presents bread prepared with yeast Pakmaya, regardless of the time of rising.

The same can be seen from the analysis of the masses of the prepared breads. Looking at the baking loss, it might be said that Rapunzel yeast is the most appropriate, but the answer is inconclusive in terms of the porosity of the core and the aspect of bread.

It can be noticed that for Rapunzel yeast doughs there are no big differences between prepared bread with different fermentation times. Differences are somewhat greater for other types of breads. If on the breads prepared with yeast Dr. Oetker and Rapunzel low mass values were recorded for fermentation time of 90 minutes, compared to the masses

for the fermentation time of 20 minutes, at breads prepared with yeast Pakmaya bread mass increased when the fermentation time was 90 minutes.
If we look at finished products in terms of core porosity (Figure 7), we could say that the bread prepared directly in the bread pan of the bread maker, i.e. with a 20 minute rising time, has a more pronounced porosity than that with a 90 minute rising time, at bread with yeast Dr. Oetker and Pakmaya. However, given the interruption of the flow to achieve a 90 minute period, the conclusion could be said to be unfounded properly.
There are not very large differences between bread with 20 minute fermentation time and that with 90 minute rising, especially for Pakmaya yeast. The visible differences are on Rapunzel yeast, a better porosity having the bread with a rising time of 90 minute. Here, the main reason is that this type of yeast requires a longer activation time (taking into account that there is a delay of the bubble swelling process of about 20 minutes).

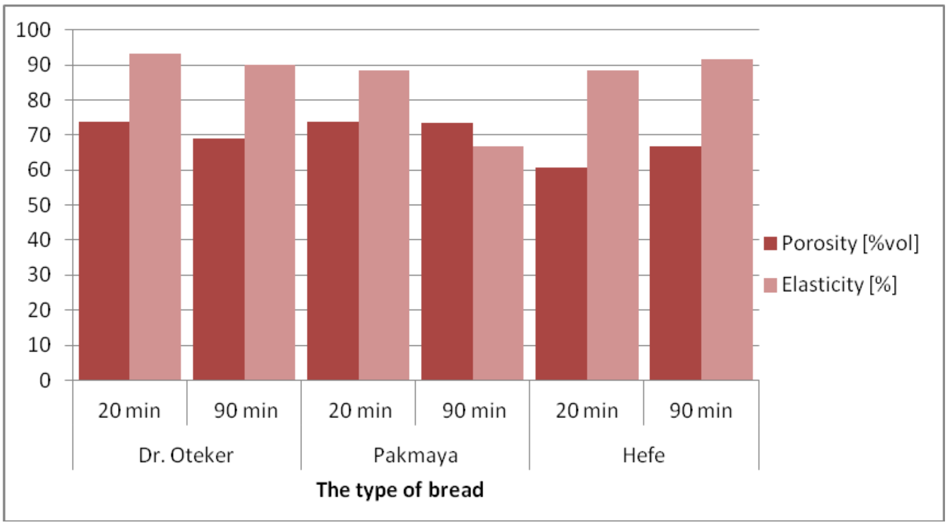


Figure 7. *Variation of the porosity and elasticity of the core*

Also, there are no great differences between the porosity values of breads prepared by yeast Dr. Oetker and Pakmaya, although the porosity of the bread core prepared with yeast Dr. Oetker at 90 minutes of rising seems to be slightly lower compared to porosity at 20 minutes of fermentation (with the same type of yeast) and that of bread prepared with Pakmaya yeast, regardless of the rising time.
In terms of core elasticity, from the analysis of the values in Table 2 a better elasticity is found in bread prepared with yeast Dr. Oetker, especially at a 20 minute fermentation time, but also for Rapunzel yeast, at a fermentation time of 90 minutes.
Lower core elasticity shows the core of bread prepared with Rapunzel yeast, at a fermentation time of 90 minutes, with about 20 % compared with bread with a 20 minute fermentation time.
Very likely the variation of the qualitative indices of the prepared breads, regardless of the time of rising, it may be due to the used recipe that shows a slightly higher amount of water relative to the normal moisturizing capacity of the flour (that is, of 65 % compared to 60 %). It must be said that was used the ingredient quantities recommended by the manufacturer of bread making machine.

CONCLUSIONS

Dough prepared with Rapunzel yeast requires a longer fermentation time comparative with doughs prepared with other commercial types of yeast.
The core of bread with Rapunzel yeast has the lowest porosity value, indicating that the dough is insufficiently fermented.
Fermentation time has influenced the elasticity of the baked bread core prepared with Pakmaya yeast.
Loss of baking is higher when using Pakmaya yeast, regardless of fermentation time, but smaller if the fermentation time increases to 90 minutes (to this type of yeast). In the other two types of dough, baking losses are higher for a 90 minute rising time.

REFERENCES

1. Nore, S., Van del Maelen, E., Hemdane, S., Verspreer, J., Verstrepen, K.J., Courtin, C.M.: Bread dough and baker's yeast: an uplifting synergy, *Comprehensive Reviews in Food Science and Food Safety*, **2017**, **16** (5), 850-867;
2. Moldoveanu, Gh., Niculescu, N.I., Margarit, N.: *Cartea brutarului*, Editura Tehnica, Bucharest, **1973**, 8-51;
3. Joachim, D., Schloss A.: The science of baking with yeast, *Fine Cooking*, **2015**, **127**, 24-25
4. Zettel, V., Paquet-Durand, O., Hecker, F., Hitzmann, B.: Image analysis and mathematical modelling for the supervision of the dough fermentation process, *19th ESAFORM Conference* **2016**, **1769** (1), 6-12;
5. Bordei, D., Teodorescu, F., Toma, M.: *Știința și tehnologia panificației,* Editura Agir, Bucharest, **2000**, 87-107;
6. Akbar, A., Aamir, S., Moazzam, R.K., Muhammad, A.S., Muhammad, R.A.: Yeast, its types and role in fermentation during bread making process-A-Review, *Pakistan Journal of Food Sciences*, **2012**, **22** (3), 171-179;
7. Roşan, C.A., Bei, M.F. : Evaluation of the fermentative potential of some bakery yeasts, *Fascicle: Ecotoxicology*, *Animal Husbandry and Food Science and Technology*, **2018**, **7** (A), 65-68 ;
8. Filip, M.L., Casian, M.V.: *Analize specifice în industria morăritului și panificației - material de învățare pentru clasa a 11-a*, Editura Risoprint, Cluj – Napoca, **2017**;
9. Rathnayake, H.A., Navaratne, S.B., Navaratne, C.M.: Porous crumb structure of leavened baked products, *International Journal of Food Science*, **2018**, **2018** (2), 1-15;
10. Kwolek-Mirek, M., Zadrag-Tecza, R.: Comparison of methods used for assessing the viability and vitality of yeast cells, *FEMS Yeast Research*, **2014**, **14** (7), 1068-1079;
11. https://www.tefal.ro/Aparate-pentru-g%C4%83tit/Ma%C5%9Fini-de-p%C3%A2ine/Ma%C8%99in%C4%83-de-f%C4%83cut-p%C3%A2ine-Pain-Plaisir-PF220838/p/7211002268, accessed April 11, **2019**;
12. Banu, C.: *Calitatea și analiza senzorială a produselor alimentare,* Editura Agir, Bucharest, **2007**, 430-432.