*Journal of Engineering Science* *Vol. XXVII, no. 3 (2020), pp. 216 - 224*
*Fascicle* *Food Engineering* *ISSN 2587-3474*
*Topic* *Biotechnologies, Food Chemistry and Food Safety* *eISSN 2587-3482*

**DOI: 10.5281/zenodo.3949722**
**UDC 664.654.1**

# THE INFLUENCE OF BIOTECHNOLOGICAL STRATEGIES ON NUTRITIONAL ASPECTS OF BAKERY PRODUCTS

Rodica Siminiuc*, ORCID ID: 0000-0003-4257-1840

*Technical University of Moldova, 168 Stefan cel Mare Bd, Chisinau, Republic of Moldova*
**rodica.siminiuc@adm.utm.md*

Received: 06. 02. 2020
Accepted: 07. 28. 2020

**Abstract.** Fermented products based on sourdough show many advantages in comparison with fermented products with commercial yeast. The research was focused on obtaining sourdough with spontaneous flora, obtaining bread samples with sourdough with spontaneous flora from wheat flour and soriz flour (*Sorghum Oryzoidum*), as well as obtaining bread with commercial yeast. As a result, the impact of the use of sourdough with spontaneous flora jelly and commercial yeast on some nutritional aspects of the bakery products obtained was analyzed, namely: changes in phytic acid content, protein digestibility, $Ca^{2+}$ and $Mg^{2+}$ content and organoleptic indices. The results obtained could be an effective alternative in the development of bakery and pastry products with mayonnaise with spontaneous flora.

**Keywords:** *fermentation, nutritional aspects, sourdough, spontaneous flora, Sorghum oryzoidum flour, wheat flour.*

## Introduction

Trends in modern baking to reduce the fermentation time in the technological process have led to the reduction of the nutritional value of bread. The development of bread products on the based on sourdough with spontaneous flora is a field of research in accordance with the requirements of the European Union to directly improve nutritional benefits of cereals, reduction of allergens, toxic compounds and increasing the safety of these products Inseparable from fermented doughs, in particular for bakery products, sourdough with spontaneous flora, is defined as a mixture based on flour and water (and possibly salt or sugar) fermented by bacteria lactic and yeasts of endogenous or exogenous origin. Obtained thanks to a successive series of refreshments which optimize the acidification and fermentation capacity [1, 2].

Thanks to the multiple refreshes, a natural selection of the micro-biota of the sourdough takes place, and thus a true ecosystem of trophic relationships is created which are dependent on the metabolic capacities of the microorganisms present. In the leaven with spontaneous flora there can be found more than 50 species of lactic bacteria (Lactobacillus) and more than 20 species of yeast (in particular Saccharomyces and Candida) [3]. The

determining factors for a balanced development of the microflora of spontaneous leaven are temperature, availability of water and food [4, 5].

The bibliographic references indicate that fermented products based on sourdough with spontaneous flora have many advantages compared to products containing baker's yeast, namely the pre-digestion of cellulose prefers and makes them easier to digest, containing important prebiotics for the digestive tract, inhibit the growth of bacteria by creating an acidic environment and producing antibacterial agents, the flavor and texture were better compared to fermented products with baker's yeast, they have nutritional value due to the increased availability of minerals and the decrease in the glycemic index [6, 7].
This research is part of the global research on the development of foods with benefits for human health.

**Materials and methods**

For the purpose of research there were baked 4 types of bread.

1 - White bread, with sourdough with spontaneous wheat flora;
2 - White bread, with sourdough with spontaneous soriz flora;
3 - White bread, with baker's yeast (wheat flour);
4 - Bread with baker's yeast (wheat flour + soriz flour).

2 types of recipes were used for baking bread. One type for bread with baker's yeast and the other for spontaneous sourdough bread. The recipes are similar, only the amount of farmer is different. Table 1 shows the special features of the recipes. For the sourdough bread, a method composed of several phases was used, the bread with baker's yeast was prepared by using direct method.

*Table 1*

**The quantity of ingredients used in preparing samples of bread**

| | Ingredients | Sourdough bread | | Bread with baker's yeast (wheat flour) | | Bread with baker's yeast (wheat flour + soriz flour) | |
|---|---|---|---|---|---|---|---|
| | | **Grams** | **%** | **Grams** | **%** | **Grams** | **%** |
| 1. | Total flour | 375 | 100 | 367 | 100 | 367 | 100 |
| 2. | Flour for wheat pre-ferment | 60 | - | - | - | - | - |
| 3. | Flour for soriz pre-ferment | 60 | - | - | - | - | - |
| 4. | Wheat flour in the dough | 285 | 100 | 367 | 100 | 277 | 75,47 |
| 5. | Soriz flour in bread with baker's yeast | - | - | - | - | 90 | 24,52 |
| 6. | Soriz flour in bread with wheat pre-ferment | 30 | - | - | - | - | - |
| 7. | Soriz flour in sourdough *any point* | 30 | - | - | - | - | - |
| 8. | Total water | 225 | 60 | 220 | 60 | 220 | 60 |
| 9. | Water in the pre-ferment | 60 | - | - | - | - | - |

*Continuation Table 1*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 10. | Water in the leaven all point | 30 | - | - | - | - | - |
| 11. | Water in the dough | 135 | 60 | 220 | 60 | 220 | 60 |
| 12. | Pre-ferment hydration | - | 100 | - | - | - | - |
| 13. | Baker's yeast | - | - | 7,4 | 2,0 | 7,4 | 2,0 |
| 14. | Salt | 5,46 | 1,5 | 5,46 | 1,5 | 5,46 | 1,5 |

*Table 2*

**Methods used for research**

***Methods for determining bread quality indices***

| | | |
|---|---|---|
| 1. | Dry substance | method according [9] |
| 2. | Titratable acidity | method according [9] |
| 3. | Porosity | method according [9] |
| 4. | Elasticity | method according [9] |
| 5. | Phytic acid content (titrimetric method) | method according [10] |
| 6. | Content of minerals Ca and Mg | AAS, Institute of Chemistry of the Academy of Science of Moldova |
| 7. | Glycemic index (*in vivo* method) | ISO 26642 |
| 8. | protein digestibility *in vitro* | method according [20] |
| 9. | Organoleptic indices | STAS 878-68 |
| 10. | Color parameters | ISO 7724 – 2, Chroma Meter CR – 410 Konika Minolta |

**Results and discussions**

**The physicochemical indices of bread**

After baking the bread, the following physicochemical indices of bread were analyzed: TTA, dry substance, porosity, elasticity, specific volume, and mass losses during baking. They are presented in Table 3.

*Table 3*

**The physicochemical indices of bread**

| Indices | Wheat flour bread with sourdough with spontaneous wheat flora; | Wheat flour bread with sourdough with spontaneous soriz flora; | Wheat flour bread with yeast | Wheat and soriz flour bread with yeast |
|---|---|---|---|---|
| **Total Titratable Acidity (TTA), degrees** | 6,0±0,1 | 6,2±0,1 | 2,6±0,1 | 3,1±0,1 |
| **Dry substance, %** | 41,5±0,1 | 38,6±0,1 | 42,2±0,1 | 40,3±0,1 |
| **Porosity, % vol** | 59,75±0,2 | 63,60±0,1 | 70,06±0,3 | 67,20±0,5 |

*Continuation Table 3*

| | | | | |
|---|---|---|---|---|
| **Elasticity, %** | 89,6±0,3 | 90,0±0,3 | 94,4±0,2 | 92,3±0,3 |
| **Specific volume, cm3 / g** | 1,89±0,1 | 2,09±0,2 | 2,55±0,2 | 2,23±0,1 |

**The dry substance** content in the bread samples was framed in the values presented in the specialty literature (30.0 - 46.0%), being 41.5; 38.6; 42.2 and 40.3 for bread with wheat pre-ferment, bread with soriz pre-ferment, bread with baker's yeast and, respectively bread with baker's yeast (addition of soriz flour).

**The total titratable acidity (TTA*)*** should be 1.5 - 4.0 degrees. For the samples of baked bread, the values 6.0 were obtained; 6.2; 2.6 and 3.1 for bread with wheat pre-ferment, bread with soriz pre-ferment, bread with baker's yeast, and, respectively bread with baker's yeast (addition of soriz flour).

The acidity values for sourdough bread are higher than those of baker's yeast bread thanks to the long fermentation process which has favored the acidification of the medium.

**The indices of porosity, elasticity, and specific volume are rheological** indices of the bread which have a correlation between them. Larger values for white bread with baker's yeast were obtained, being 70.06; 94.4 and 2.55, for bread with baker's yeast (addition of soriz flour) 67.20; 92.3 and 2.23.

For bread with soriz pre-ferment- 63.60; 90.0; 2.09 and for bread with wheat pre-ferment 59.75; 89.6 and 1.89.

The higher values obtained for sourdough bread can be explained by the presence of the numerous yeast cells which promote the growth of the volume of the dough. In figure 3.9 the mass losses are shown during the baking of the bread.

***Losses during the baking*** of the bread take place thanks to the dehydration of the surface layers of the dough which, when baked, turns into a crust.

The level of technological losses during baking depends on several factors: the mass of the dough piece, the shape, the temperature in the baking chamber, the specific volume of the bread.

If the initial humidity of the bread is high, then the losses when baking the bread are also high. In figure 3. we have a value of 11.6% for white bread with baker's yeast; 11.2% for bread with baker's yeast and addition of soriz flour; 10.2% for bread with sourdough of wheat and 9.92% for bread with sourdough of soriz.

It is observed that the mass losses for bread with sourdough are smaller than bread with baker's yeast. In general, the losses for a piece of dough with 0.5 - 1 kg must be between 10 - 12% [8].

**The nutritional aspects of bread**

**Determination of phytic acid.** Flour, particularly whole wheat, is reported to contain appropriate amounts of mineral salts such as potassium, magnesium, zinc, and iron.

However, cereal flour contains phytates (phytic acid, PA, myo-inositol hexakisphosphate) which chelate polyvalent cations, which makes them unavailable for absorption (Table 4).

*Table 4*

**Content of phytic acid in different foods** [10; 11]

| Food | Content of phytic acid,% of dry weight |
|---|---|
| **Corn** | 0,39...1,35 |
| **Wheat flour** | 0,25...1,37 |
| **Bread with integral wheat flour** | 0,45...1,05 |
| **Soriz** | 1,8...2,3 |
| **Rye** | 1,0...2,1 |
| **White bread** | 0,03...0,23 |
| **Spontaneous rye sourdough** | 0,03 |

Bread-making is a particular type of fermentation and degradation of phytic acid which can be considerable, depending on the ingredients and the fermentation conditions. During the preparation of leavened rye bread, phytic acid was reduced with 80%, while in wheat bread with 25-60% of the initial content was degraded [9].

Fretzdorff and Brummer (1992) showed that the breakdown of phytic acid during the preparation of bread depended mainly on the pH and phytase of natural origin in flour [10, 12].

*Table 5*

**Phytic acid content in bread**

| Bread samples | Phytic acid content, % |
|---|---|
| Wheat and soriz flour bread with yeast | 0,36±0,4 |
| Wheat flour bread with yeast | 0,22±0,1 |
| Wheat flour bread with sourdough with spontaneous soriz flora; | 0,17±0,1 |
| Wheat flour bread with sourdough with spontaneous wheat flora | 0,05±0,05 |

During bread fermentation, the amount of phytic acid decreases significantly given the activity of the enzyme phytase present in both flour and yeast. Depending on this hydrolysis of phytic acid, only whole meal bread still retains a demineralizing action [12].

Phytates in wheat are greatly reduced during sourdough preparation, wheat is also rich in phytase. Bread with baking yeast cannot completely reduce the level of phytic acid. The decrease in phytates is significantly higher in sourdough bread than in ordinary bread [13].

The results obtained for the analyzed samples show a difference between the two fermentations that were performed. Higher values were obtained for bread that contains soriz flour because this type of flour is rich in sounds.

The highest value of phytic acid was obtained for bread with baking yeast and soriz flour being 0.36%, for spontaneous sourdough bread containing the same amount of soriz flour was obtained the value of 0,17%. White bread with baking yeast has a phytic acid content of 0.22% and sourdough bread with wheat yeast has 0.05% (Table 5).

The more basic values in sourdough bread can be explained by the relationship between the livestock agent used and the acidity present at the time of dough fermentation. The high acidity in the pulp initiates the activity of the enzyme phytase,

which acts in the pH range between 4.1 and 4.5, an area close to the optimum action of the enzyme degrading the phytic acid.

Fermentation time is also a factor that has the greatest influence on phytic acid degradation. The longer it lasts, the lower the phytic acid content [10, 11].

**Determination of protein digestibility** in *vitro*. The process of digestion of food nutrients (carbohydrates, proteins, lipids) is carried out as part of hydrolytic biochemical processes, which are ensured by the participation of many digestive enzymes. Before the action of digestive enzymes, simple, absorbable products are obtained [2].

Protein digestion begins with pepsin in gastric juice and ends with pancreatic juice proteases (trypsin, chymotrypsin, elastase, carboxypeptidases), and intestinal mucosa cells (aminopeptidase, dipeptidase).

Several factors play an important role in enzyme activity. Intrinsic factors are food, including the presence of anti-nutritional substances (inhibitors of protease, lectins, polyphenols, and phytates), protein conformation, protein interaction with other components alimentaires.

Extrinsic factors include technological food treatments, primarily heat treatment, which can reduce the nutrient content and increase the digestibility of proteins [14].

In vitro digestibility analysis with trypsin on bread samples showed that prolonged fermentation with spontaneous yeast increases digestibility values.

*Table 6*

**Degree of digestibility of bread proteins**

| Bread samples | Digestibility, % |
|---|---|
| Wheat and soriz flour bread with yeast | 68±1,0 |
| Wheat flour bread with yeast | 69±1,0 |
| Wheat flour bread with sourdough with spontaneous soriz flora; | 82±1,6 |
| Wheat flour bread with sourdough with spontaneous wheat flora | 89±2,1 |

It has been found that in the case of long leaven fermentation the digestibility increases, having values of 82% for bread with spontaneous wheat yeast compared to 68% for white bread with baking yeast.

The highest digestibility value was obtained for bread with spontaneous soriz yeast 89% and bread with baking yeast and with the same amount of soriz flour being 69% (Table 6).

Technological treatments cause protein degradation and denaturation, as well as making them easier to digest due to intermolecular rupture and subsequent deployment of the protein structure, which facilitates the availability of digestive enzymes, or more difficult to digest by the formation of new molecular interactions (crosslinking), which are little attacked by digestive system enzymes.

The higher values of protein digestibility for sourdough bread can be explained by the fact that during a long fermentation (more than 8 h), the cleavage of proteins into amino acids takes place, it causes the structural modification of proteins which improves the flexibility and accessibility of proteases and subsequently the digestibility of proteins.

**Determination of minerals ($Ca^{2+}$ and $Mg^{2+}$) in bread.** Yeast fermentation has a significant impact on the bioavailability of minerals. This is due to the fermentation of lactic acid bacteria and wild yeasts. They produce organic acids (AA and LA) after which natural acidification occurs. Also, there is the metabolism of amino acids that produce aromas and EPS [15].

The bioavailability of minerals takes place through the acidification of the medium which causes the activation of plant and microbial phytases, also takes place the activation of xylanases which increases the viscosity [16].

*Table 7*

**Concentration of minerals in bread samples**

| Bread samples | $Ca^{2+}$, *mg/kg* | $Mg^{2+}$, *mg/kg* |
|---|---|---|
| Wheat and soriz flour bread with yeast | 370,1±11,1 | 270,1±8,9 |
| Wheat flour bread with yeast | 390,5±9,7 | 415,0±15,0 |
| Wheat flour bread with sourdough with spontaneous soriz flora; | 391,5±9,7 | 320,5±9,0 |
| Wheat flour bread with sourdough with spontaneous wheat flora. | 451,5±13,2 | 489,5±6,4 |

The results presented in Table 3.12 show that the mineral content is higher in samples with spontaneous sourdough having higher values than bread with baking yeast. The maximum content was obtained in bread with sourdough soriz flora, with values of 451,2 mg / kg for $Ca^{2+}$ and 489,5 mg / kg for $Mg^{2+}$ (Table 7).

**Sensory analysis of bread.** The flavour of sourdough baked goods is influenced by raw materials, sourdough fermentation, type of entrees, and proofing and cooking conditions. The ratio of lactic acid to acetic acid is an important factor affecting the aroma of the final bread, and it is influenced by the fermentation of microorganisms, the fermentation temperature, and the type of flour [14]. Optimal use of sourdoughs can improve taste and flavour. The flavour of wheat sourdoughs bread is richer and more aromatic than wheat bread with baking yeast, a factor that can be attributed to the yeast's long-lasting fermentation time. The concentration of 2-phenyl ethanol, one of the most potent odorous substances in wheat bread crumbs, increases in sourdough bread crumbs.

During the fermentation of the acid pulp different organic acids are produced. These organic acids enhance the flavour of the bread, promoting gluten swelling and gas retention, resulting in products with improved texture [17, 18]. The acids produced during fermentation strongly influence the way the dough is mixed, and the dough with lower values requires a slightly shorter mixing time. The development of a fermentation step based on endogenous flora leads to the hydrolysis of 55-70% of the present phytates, which ensures the solubility of the mineral elements [19, 20]. The presence of organic acids has a favorable influence, because lactic acid forms with compounds complex compounds, capable of penetrating the gastrointestinal barrier, forming competition with phytates. Bread obtained with spontaneous sourdough is richer in aromatic compounds, thanks to the organic acids formed during a long period of fermentation [21]. Breads that are not well ventilated compared to baking yeast bread have not been obtained. The sensory qualities are in favour of spontaneous sourdough bread.

**Conclusions**

Spontaneous sourdough technology, a traditional process, when combined with modern manufacturing techniques, could yield healthier products for consumers. Sourdough has also been shown to be useful in bread production with slow digestibility of starch and therefore low glycemic responses.

The use of sourdough is useful to manufacture bakery products with an increased level of aromatic compounds, ultimately increasing the regularity in batches and customer satisfaction. Sourdough technology can also be helpful while reducing or eliminating the level of preservatives often used in bakery products.

- The acidity of bread samples with spontaneous sourdough was between 6,0 – 6,2 degrees, being two times higher than bread samples with baking yeast;
- The structure indices (porosity, elasticity, specific volume) of bread samples with baking yeast had higher values compared to bread with spontaneous sourdough, probably due to the reduced amount of gluten, being a higher intake of flour of soriz;
- Research has shown that the involvement of sourdough with spontaneous flora in the production of bakery products and the long duration of fermentation has influenced the nutritional aspects of bakery products and in particular:
  - The content of phytic acid was reduced, about 2 times in the samples with sourdough and pre-fermentation of soriz flour and about 7 times for the samples with yeast and pre-fermentation of wheat flour;
  - Increased protein digestibility was obtained from 69% (for baking yeast bread samples) to 82% and 89% for spontaneously sourdough bread samples;
  - Increased the bioavailability of minerals ($Ca^{2+}$ and $Mg^{2+}$);
  - The acidity of the products was increased, by obtaining products with more intense taste and aroma.
- The involvement of biotechnological strategies (the use of spontaneous sourdough and long fermentation processes) while developing bakery products could contribute to the diversification of bakery products, the increase in nutritional value and to the growth of food insurance.

**References**


1. Siminiuc R. *Technological and nutritional aspects of soriz products (Sorghum oryzoidum):* Ph.D Thesis. Chișinău (Moldova): Universitatea Tehnică a Moldovei, 2014 (in Romanian)
2. Bădărău I. A. *Digestion and absorption. "Carol Davila" University Publishing House, Bucharest 2000, p. 195.*
3. Gobbeti M., De Angelis M., Corsetti R., Di Cango R. *Biochemistry and physiology of sourdough lactic acid bacteria*. Trends Food Sci. Technol. 16, 57-69, 2005.
4. Reddy Nr., and others. *Food Phytates*, 1st edition, CRC Press, 2001, p. 30-32.
5. Taylor S. *Advances in Food and Nutrition Research*. Academic Press, USA, vol. 49, 2005, p. 336. ISBN 0-12-016449-3.
6. Bartosz K. Buckzkovski. *Sourdough bread enriched with soluble fibers: development, characterisation and nutritional aspects of a functional food product*. Department of food and tourism management, Manchester Metropolitan University, April 2013.
7. Carnevali P., Ciati R., Leporati A., Paese M. *Liquid sourdough fermentation: Industrial application perspectives*. Food Microbiology 24. pp.150-154. Barilla G&F f. lli SpA, 2007.
8. Didar Z. *Effect of Sourdough on Phytic Acid Content and Quality of Iranian Sangak Bread*. Islamic Azad University, Neyshabur, Branch, Iran. ISSN: 2155 – 9600 JNFS, 2009.
9. Lupu O. *Theoretical bases of bakery*. UTM, Chisinau 2007, p. 75. (in Romanian).
10. Benešová K., Běláková S. *Survey of the Analytical Methods for the Phytic Acid Determination*. *Výzkumný ústav pivovarský a sladařský,a.* s., Mostecká 7, 614 00 Brno / Research Institute of Brweing and Malting, plc, Mostecká 7, 614 00 Brno.

11. Sun J., Beong O. et al. *In vitro human digestion models for food application*. National Research Foundation of Korea Grant funded by the Korean Government (KRF-2009-353-F00006). Food Chemistry 125 (2011) 1-12.
12. Ines M. *Traditional food processing methods to increase the bioavailability from cereal and legume based weaning foods*. Swiss Federal Institute of Technology Zurich. *Journal of Agriculture and Food Chemistry* 49 (5), pp 2657−2662 DOI: 10.1021/jf001255z Publication Date (Web): May 4, Copyright © 2001 American Chemical Society.
13. Guinet R., Godon D. *La panification française*. INRA, Technique et documentation – Lavoisier, Paris, p. 521, 1994.
14. Varapha L., Edgar Chambers IV, Delores H. Chambers. *Determination of the sensory attributes of wheat sourdough bread*. The sensory analysis center, Justin Hall, Kansas State University, Manhattan, Kansas 66506-1407, 2007.
15. Rupesh S., Chavan Shraddha R. Chavan. *Sourdough Technology – A Traditional Way for Wholesome Foods*. Institute of Food Technologists, vol. 10, 2011, p. 170-183.
16. Siminiuc R., Rubțov S., Vizireanu C., Sturza R., Scurtu A. *Certains aspects microbiologiques de levain avec la flore spontanne*. 7th International Euro-aliment Symposium. All about food. 24-26 september, 2015. Galați, România.Disponibil: http://www.euroaliment.ugal.ro/euro-aliment_2015.htm.
17. Siminiuc R., Vizireanu C. *L'impact du levain spontane sur l'indice glycemique des produits de panification*. 7th International Euro-aliment Symposium. All about food. 24-26 september, 2015. Galați, Romania. Disponibil: http://www.euroaliment.ugal.ro/euro-aliment_2015.htm.
18. Siminiuc R., Coşciug L., Rubţov S., Balan I., Vidraşco A. *Quality indexes of spontaneous flora sourdough of different flours*. Modern Technologies, in the Food Industry, 2014, p. 287-292. Disponibil: https://ibn.idsi.md/sites/default/files/imag_file/MTFI_2014-287-292.pdf.
19. Ciobanu C., Sturza R., Deseatnicov O. *Optimisation of potential iron bioavailability in fortified bakery products through application of a lactic acid fermentation stage*. The annals of of the University Dunarea de Jos of Galati, Galati, p.6-11, 2007, ISSN 1843-5114.
20. Sturza R., Deseatnicov O., CiumaC J. *L'effet des procedes de panification sur la biodisponibilite du calcium*. J. Of the University of Chemical Technology and Metallurgy, Sofia, Bulgarie, 2002, vol. XXXVII, No. 5, ISSN 1311-7629.
21. Sturza R., Deseatnicov O., Subotin Iu. *Wine leaven in bread baking*. In Scientific works: „Food science, Technique & Technologies", University of Food Technologyes, V.L, Issue 2, Plovdiv, 2003.