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ORIGINAL RESEARCH PAPER

THE EFFECT OF SOME TECHNOLOGICAL FACTORS ON THE RYE SOURDOUGH BREAD♦

Iuliana Banu*, Ina Vasilean (Simitaru), Vasilica Barbu, Catalin Iancu

University"Dunărea de Jos" of Galaţi, Faculty of Food Science and Engineering, 111 Domnească street, 800201, Galaţi, Romania

*Corresponding author: iuliana.banu@ugal.ro

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Abstract: The modern biotechnology of bread production uses sourdough as a natural leavening agent. In rye bread making the sourdough is essential. The aim of this paper was to examine the influence of starter culture types, flour extraction rate, dough yield and temperature of fermentation on the quality of the sourdough rye bread. The sourdough was prepared using a mixed culture of *Lactobacillus plantarum* and *Lactobacillus brevis*. The rye breads prepared with 20% sourdough and bread with no sourdough were investigated. The addition of sourdough increases the loaf specific volume relative to control sample. The best results were obtained in case of sourdough made from dark rye flour, 300 dough yield, after 24 h fermentation at 30 °C. The porosity of the bread was estimated by analyzing the scanned images of the vertically halved bread. Digital image analysis revealed that the cell-to-total area ratio was lower for the sourdough prepared with whole rye bread.

Keywords: *bread, LAB, rye, sourdough, technological factors*

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INTRODUCTION

The modern biotechnology of bread production uses sourdough as a natural leavening agent [1]. Sourdough is a mixture of flour and water that is fermented with lactic acid bacteria (LAB) and yeast to reach a *p*H value below 4.5. The levels of LAB in sourdough are 10^8 – 10^9 CFU.g^{-1}, and the LAB : yeast ratio is generally 100 : 1. The advantages of using sourdough in bread making are: the possibility of leavening bread dough with a little or no baker's yeast added, improved dough properties, increased flavor and taste of bread, improved nutritional value and extended shelf life of the sourdough bread.
There are three type of sourdough described in the literature [2 – 5]. Type I sourdoughs are traditional dough prepared in three fermentation stages at temperatures between 20 to 30 °C. The dominant LAB in these doughs are *Lb. sanfransciscensis* and *Lb. pontis*. Type II sourdoughs are achieved by the addition of baker's yeast to the dough, fermentation temperature exceeding 30 °C. The dominants LAB in type II sourdough are *Lb. pontis*, *Lb. reuteri*, *Lb. fermentum*, *Lb. brevis*, *Lb. delbrueckii*, *Lb. acidophilus* etc. Type III sourdoughs are dried preparations of dough. The LAB in these dough are resistant to drying and includes *Lb. plantarum* and *Lb. brevis* [6].
The quality of the sourdough bread is influenced by the microbial flora (starter cultures of LAB and yeasts), flour type (rye/wheat, flour extraction rate), flour/water ratio (dough yield), and the process parameters such as temperature, initial *p*H, quantity of sourdough incorporated in dough, time of fermentation [1].
In rye bread making the sourdough is essential. One of the main achievements of sourdough fermentation consists in the inactivation of the α-amylase activity, since its activity in the rye is really high.
The aim of this paper was to examine the influence of starter culture types, flour extraction rate, dough yield and temperature of fermentation on the quality of the sourdough rye bread.

MATERIALS AND METHODS

Materials

Commercial whole rye flour (1.9% ash content and 308 s falling number value) and dark rye flour (1.3% ash content and 346 s falling number value) retailed on the local market (Galați, Romania) was used in this study.
Microbiological cultures used in the studies were *Lb. plantarum* (15GAL) and *Lb. brevis* (16GAL) from MIUG collection (Food Science and Engineering Faculty, Galati, Romania) [7, 8], and commercial strains *Lb. plantarum* and *Lb. brevis* (DI-PROX MTTX), from EDR Ingredients (Costişa, Neamț, Romania), in combination with *S. cerevisiae*.

Sourdough fermentation

Sourdoughs were prepared by mixing tap water, rye flour and inoculum of LAB, thereby giving a dough yield [DY = (mass of dough/mass of flour) × 100] of 150, 200 and 300, in a large beaker. After covered with aluminum foil the beakers were incubated at 30 °C and 37 °C for 24 h.
The size of inoculum for LAB from MIUG collection was $(3\div5)\times10^8$ CFU/100 g dough. In case of commercial strains the inoculum was prepared according the of producer recommendations (EDR Ingredients Romania).

***p*H, acidity and cell counts**

Measurements of *p*H and total titratable acidity (TTA) were performed according to the Romanian standard methods 90/2007 [9]. The TTA value is defined as the amount of 0.1 N NaOH solution (mL) used to neutralize 10 g sample weight.
Cell counts of LAB and yeasts were determined by the viable cell count method on mMRS agar and Sabouraud agar in duplicates using appropriate dilution of dough. The plates were anaerobically incubated at 37 °C for 48 h. Results were expressed as CFU/g (colony forming units per gram dough).

Baking tests

The bread formula contained 20% sourdough, rye flour (dark flour, respectively whole flour), water, baker's yeast and salt. The dough was prepared at 28 ºC by mixing in a laboratory mixing device. After fermentation for 30 min at 28 ºC in a laboratory proofer, the dough was divided in pieces which were molded and placed in baking tins. After a final leavening of 45 min, the trays were introduced into the oven. The samples were baked at 260 ºC for 40 min (the steam tap was turned on for 10 – 15 s before placing them into the oven).
Control samples were rye bread, from dark and whole rye flour, without sourdough.

Bread evaluation

Bread volume, *p*H and total titratable acidity were performed according to the Romanian standard methods 90/2007. The porosity of the bread was estimated by analyzing the scanned images of the vertically halved bread by means of the Image J software [10] that uses the contrast between the two phases (pores and solid part) in the image. The scanned color images were first converted to gray scale. Using bars of known length, pixel values were converted into distance units. The largest possible rectangular cross-section of the bread halves was cropped. After adjusting the threshold, the pores areas as fraction of total area were determined using the software.

RESULTS AND DISCUSSION

*p*H and total titratable acidity

After 24 h of fermentation *p*H values of the sourdough were ranged 4.11 and 4.15 in case of the samples obtained with dark rye flour and DI-PROX MTTX, DY 300 at temperature of 30 and 37 ºC, respectively. In case of the sourdough obtained with whole rye flour, *p*H values of the sourdough were ranged 3.97 and 3.93. In case of the sourdough prepared with MIUG starters, after 24 h of fermentation, the *p*H value was much lower (3.42), for the DY was 300 and temperature of 30 ºC.
The extraction rate of the flour is one the most important factors influencing the TTA of sourdough. According Hansen [1] the final TTA in sourdoughs made from whole meal flour (ash content about 1.5%) is almost double compared to sourdoughs made from white flour (ash content about 0.55%). In our research high differences in terms of TTA were observed between sourdough made with dark rye flour and whole rye flour. The TTA was 12.27 in case of the sourdough made with dark rye flour, DY 300, after 24 h of fermentation at 30 °C, while in case of the high extraction rate (sourdough made with whole rye flour) the TTA was 14.52. This difference can be explained by the buffering capacity of the flour. In addition, Katina *et al.* [11] showed that the differences between falling number values are also important. The sourdough made from rye with falling number value of 110 s was more acidic (*p*H and TTA value were 3.9 and 17, respectively), in comparison to sourdough made from rye with falling number value of 208 s (*p*H and TTA value were 4.9 and 9, respectively). The water content in the sourdough, expressed as the dough yield had, no significant influence on the production of the lactic acid, whereas the production of acetic acid is generally lower in fluid sourdoughs [1]. The water content in sourdoughs influences the acidification of the dough more than the temperature.
The sourdough rye bread had a lower *p*H and a higher TTA (*p*H from 5.1 to 5.3, and TTA from 5 to 5.4), in comparison to control rye bread sample (*p*H 6.1, and TTA 2.5).

Cell counts of LAB and yeasts

Cell viability of LAB was better in firmer dough (DY 150), reaching maximum values of cell counts of 1.6×10^9 CFU/g dough and 1.76×10^9 CFU/g dough in case of the whole rye flour, and dark rye flour, respectively (fermentation with MIUG starters, for 24 h at 37 °C). At 30 °C cell counts of LAB were 3.6×10^8 CFU/g dough and 5.4×10^8 CFU/g dough. For DI-PROX MTTX starters total count of 4.5×10^8 CFU/g dough and 4.1×10^8 CFU/g dough were obtained for DY 150, whole rye flour at 37 and 30 °C, respectively. Cell viability of yeasts ranged from 5.9×10^7 to 9.2×10^7 CFU/g dough.

Bread quality

The specific volume of the bread was higher for sourdough rye bread in comparison with the control rye bread sample. The highest values of the specific volume were obtained in case of sourdough bread made from dark rye flour, with DY 300, and temperature of 30 °C (Table 1). In Figure 1 the images of the crumb bread realized at

the stereomicroscope with integrated camera are presented. Digital image analysis revealed that the cell-to-total area ratio was lowest for the sourdough whole rye bread (Table 1).

Table 1. *Rye bread quality*

Quality indexes	Dark rye flour				Whole rye flour			
	Dough yield							
	150		300		150		300	
	Temperature [°C]							
	30	37	30	37	30	37	30	37
Specific volume [g.cm^{-3}]	1.73	1.35	1.78	1.7	1.49	1.48	1.54	1.43
Cell-to-total area ratio	0.571	0.721	0.939	0.869	0.495	0.679	0.618	0.525

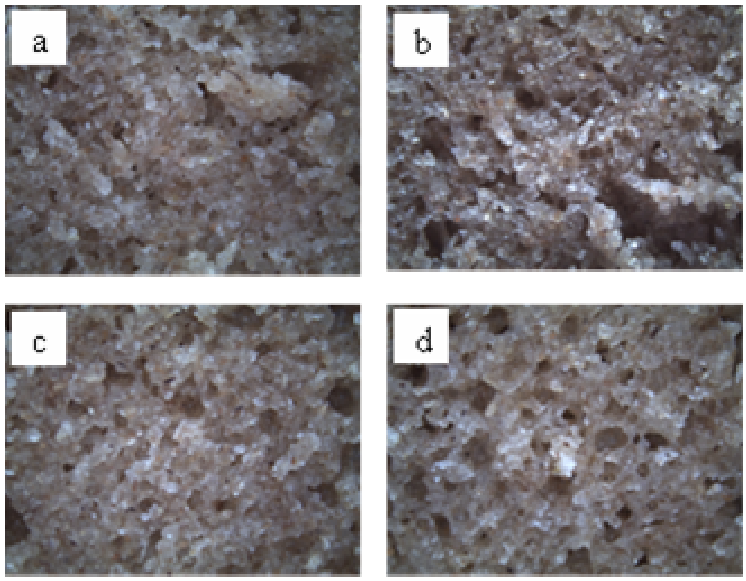

Figure 1. *The images of the crumb rye bread realized at the stereomicroscope with integrated camera: a – dark flour, dough yield 150, 24 h /30 °C; b – dark flour, dough yield 150, 24 h/37 °C; c – dark flour, dough yield 300, 24 h/30 °C; d – dark flour, dough yield 300, 24 h/37 °C*

CONCLUSIONS

Quality of the rye sourdough bread depends by the starter culture types, flour extraction rate, dough yield and temperature of fermentation. The best results were obtained in case of sourdough made from dark rye flour, when a 300 dough yield and a fermentation of 24 h at 30 °C were used.

The addition of sourdough increases the loaf specific volume relative to control sample. Digital image analysis revealed that the cell-to-total area ratio was lower for the sourdough whole rye bread.

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