The use of active bakery ingredients in bakery products of functional purpose

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Abstract. The paper describes the possibility of changing of yeast to natural sourdoughs of spontaneous fermentation in bakery products formulations with using of ‘BackNatur’ and ‘O-tenic’ active bakery ingredients. The influence of fermentation temperature and time on the quality of liquid sourdoughs is described, and the content of microorganisms in dried and liquid sourdoughs is shown. There were developed the formulations of bakery products based on the sourdoughs with using of demineralized dried whey, fine mechanochemically treated eggshell powder and infrared-dried carrot powder. All samples were evaluated on their sensory, physicochemical and microbiological characteristics. The consumption of the developed bakery products satisfies from 10 to 15% of daily requirement for people in β-carotene, dietary fiber, calcium and proteins. The developed bakery products can be recommended as functional bakery products for dietary and gerontological nutrition.

1. Introduction

Development of formulations and technologies of bakery products with using of natural sourdoughs of spontaneous fermentation is one of the main directions in modern baking industry [1–3]. The sourdoughs with different compositions are extremely popular because the reduction of bakery yeast and other traditional ingredients (for example, salt and sugar) in bakery products is highly needed [4–7]. The use of sourdoughs in bakery products formulations allows to improve their quality, enrich them with various useful nutrients prevent the occurrence of molds and so-called ‘potato disease’ in them [8–10].

The purpose of the studies was the development of technology of bakery products based on dried and liquid sourdoughs of spontaneous fermentation.

2. Materials and methods

2.1. Active bakery ingredients samples

For the preparing of liquid sourdough, there were used the ‘BackNatur’ active bakery ingredient, which consists of spelt flour, flower honey and sea salt, and the ‘O-tenic’ active bakery ingredient, which consists of wheat and rye dried sourdoughs of spontaneous fermentation.

There were used or prepared the following samples of active bakery ingredients for dough fermentation:

- active bakery ingredient sample № 1 (control sample) – ‘Luks’ pressed bakery yeast;
- active bakery ingredient sample № 2 – ‘O-tenic’ dried sourdough;
• active bakery ingredient sample № 3 – liquid sourdough prepared from first-grade wheat flour, water and the ‘BackNatur’ bakery ingredient;
• active bakery ingredient sample № 4 – liquid sourdough prepared from first-grade wheat flour and whole grain wheat flour in ratio 1:1, water and the ‘BackNatur’ bakery ingredient.

The ‘BackNatur’ ingredient was used in amount of 20% from flour weight. The sourdough fermentation process was hold in thermostat at 26 °C during 12, 24 and 36 hours.

The properties of sourdough samples were evaluated on their total acidity by titrimetric method.

The microbiological composition of sourdough samples was also evaluated. The microorganism cells content was calculated by the method of quantity of mesophilic aerobic and facultative anaerobic bacteria (QMAFAnM) determination.

2.2. Bakery products samples

There were developed the following samples of bakery products based on sourdough samples and additional supplements:

• bakery product sample № 1 (control) – based on pressed yeast with demineralized dry whey, oat-flakes, fine carrot powder of infrared drying and mechanochemically treated eggshell powder;
• bakery product sample № 2 – based on the ‘O-tenic’ dried sourdough with demineralized dry whey, oat-flakes, carrot and eggshell powders;
• bakery product sample № 3 – based on the ‘O-tenic’ dried sourdough with whole grain wheat flour mixed with first-grade wheat flour in ratio 1:1, demineralized dry whey, oat-flakes, carrot and eggshell powders;
• bakery product sample № 4 – based on the ‘BackNatur’ liquid sourdough with demineralized dry whey, oat-flakes, carrot and eggshell powders;
• bakery product sample № 5 – based on the ‘BackNatur’ liquid sourdough with whole grain wheat flour mixed with first-grade wheat flour in ratio 1:1, demineralized dry whey, oat-flakes, carrot and eggshell powders.

Demineralized dry whey contains complete proteins (albumins and globulins), lactose, highly dispersed milk fats, macro- and microelements (magnesium, potassium, calcium, phosphorus, nicotinic acid, biotin, choline, B-group vitamins, vitamins A, C, E and organic acids [11]. It also has antifungal properties [12]. Fine mechanochemically-treated eggshell powder also contains complete proteins, calcium, phosphorus and other useful macro- and microelements [11]. Using infrared-dried carrot powders allows not only to enrich bakery products with β-carotene and fibers [13], but also to increase calcium digestibility.

All bakery product samples were evaluated on sensory characteristics according to Russian national standard GOST 5667-65 “Bread and bakery products. Rules of acceptance, methods of sampling, methods for determination of organoleptic characteristics and mass”. Physico-chemical and microbiological characteristics were evaluated according to standard methods.

3. Results and discussion

3.1. Active bakery ingredients

The influence of fermentation temperature and time on total acidity of active bakery ingredients is presented in table 1.

The results show that for the ‘O-tenic’ dried sourdough (sample № 2) the optimal fermentation time is 1 h, wherein the sample acidity value is 18.0 °N. For the samples № 3 and № 4 based on the ‘BackNatur’ liquid sourdough, the optimal fermentation time for sample is 36 h. The acidity values of the samples are 11.9 °N and 12 °N accordingly.
Table 1. Influence of fermentation temperature and time on total acidity of active bakery ingredients samples.

| Samples                              | Technological parameters | Acidity, °N |
|--------------------------------------|--------------------------|-------------|
|                                      | Fermentation temperature, °C | Fermentation time, h |
| Active bakery ingredient sample № 1 | 26                        | 1.0         | 4.0±0.1 |
| Active bakery ingredient sample № 2 | 26                        | 0.5         | 16.5±0.2 |
|                                      |                           | 1.0         | 18.0±0.1 |
|                                      |                           | 1.5         | 17.8±0.1 |
| Active bakery ingredient sample № 3 | 26                        | 12          | 10.0±0.2 |
|                                      |                           | 24          | 11.7±0.1 |
|                                      |                           | 36          | 11.9±0.2 |
| Active bakery ingredient sample № 4 | 26                        | 12          | 10.0±0.2 |
|                                      |                           | 24          | 11.5±0.1 |
|                                      |                           | 36          | 12.0±0.2 |

During sourdough and yeast fermentation the microorganisms are in mobile equilibrium. The difference between these two kinds of fermentation is that in the yeast dough prevails the yeast fermentation, and in the sourdough-based dough prevails the lactic-acid fermentation. In comparison with yeast, in sourdoughs there is more intensive accumulation of organics acids because of bacterial activity. Thus, the pH value of sourdough-based dough is lower than the pH value of yeast dough, and the acidity value is accordingly higher.

Results of QMAFAnM determination in active bakery products samples are presented in table 2.

Table 2. Quantity of mesophilic aerobic and facultative anaerobic microorganisms (QMAFAnM) in active bakery products samples.

| Samples                              | Quantity, CFU/g |
|--------------------------------------|-----------------|
| Active bakery ingredient sample № 1 | 1.1·10⁶         |
| Active bakery ingredient sample № 2 | 4.0·10⁴         |
| Active bakery ingredient sample № 3 | 1.0·10⁴         |
| Active bakery ingredient sample № 4 | 2.5·10⁴         |

According to obtained data, it can be concluded that all active bakery ingredient samples fulfill the requirements of “Technical regulation of Customs union on the safety of food production” (TR TS 021/2011)

3.2. Bakery products samples
The results of sensory evaluation of choux pastry semi-finished products are shown in figure 1.

The evaluation results show that samples № 2 and № 3 based on the ‘O-tenic’ dried sourdough have got better sensory characteristics than sample № 1, have fine appearance, nice taste and smell and high-porous consistency. Samples №4 and № 5 based on the liquid sourdough have got average sensory characteristics because of lower porosity, raw baked crumb and flavorless taste. The sensory characteristics decrease in these samples can be explained by low time of dough fermentation and dough pieces proofing.

The results of physico-chemical characteristics evaluation of bakery products samples are shown in table 3. According to them, the following conclusions can be made.
Figure 1. Sensory evaluation of bakery products with active bakery ingredients samples.

Table 3. Physico-chemical characteristics of bakery products samples.

| Characteristics         | Bakery product sample № 1 | Bakery product sample № 2 | Bakery product sample № 3 | Bakery product sample № 4 | Bakery product sample № 5 |
|-------------------------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|
| Humidity, %             | 40.4±0.1                   | 35.63±0.13                 | 34.63 ±0.4                 | 38.5±0.4                   | 40.16±0.35                 |
| Porosity, %             | 79.0±0.02                  | 60.3±0.049                 | 58.49±0.056               | 19.39±0.046               | 23.87±0.035               |
| Specific volume, cm³/g  | 2.12±0.05                  | 1.92±0.03                  | 1.84±0.043                | 0.94±0.045                | 1.01±0.05                 |
| Cellulose content, g/100g | 3.1±0.01                | 3.1±0.01                  | 3.5±0.03                  | 3.1±0.01                  | 3.47±0.04                 |
| Calcium content, mg/100g | 480.0±0.03                | 479.0±0.003                | 480.0±0.04                | 483.0±0.05                | 481.0±0.024               |
| Protein content, g/100 g | 9.65±0.1                  | 9.62±0.5                  | 9.63±0.12                 | 9.61±0.12                 | 9.6±0.12                 |
| β-carotene content, mg/100g | 0.75±0.07                | 0.75±0.07                  | 0.75±0.07                 | 0.75±0.07                 | 0.75±0.07                 |
| Acidity, ºN             | 1.9±0.01                   | 2.5±0.02                   | 2.9±0.01                  | 2.3±0.02                  | 2.8±0.02                  |
| Antioxidant activity (AOA), mcg/100 g | 0.46∙10³±0.05 | 0.46∙10³±0.0 | 0.46∙10³±0.0 | 0.46∙10³±0.05 | 0.46∙10³±0.05 |

The porosity and specific volume values for products samples based on dried sourdough are 60.3% and 1.92 cm³/g accordingly for sample № 2 and 58.49% and 1.84 cm³/g accordingly for sample № 3. These values are a little lower than the porosity and specific volume values of sample № 1, and they decrease with the addition of whole grain wheat flour into the dough formulations. The samples № 4 and № 5 based on liquid sourdough the above-mentioned values are low, which is explained by low gas generation ability of both sourdough itself and dough pieces.

Based on physiological need in 90 g of proteins, 5 mg of β-carotene and 1000…1200 mg of calcium per day and their functionality percentage of 15% (9 g for proteins, 0.75 g for β-carotene and 150…180 mg for calcium), it is established that all samples fulfill more than 15% of daily norm for β-carotene and calcium. For protein, there are about 10% from their daily norm, which is not enough for functionality, but just enough to say that all bakery products samples are enriched with protein (more than 5% of daily norm).
By adding of oat-flakes and whole grain wheat flour into bakery products formulations, the products are enriched with cellulose more than 10% of daily norm according to Russian “Recommended levels of alimentary and biologically active substances” (MR 2.3.1.1915-04).

All samples were evaluated on their microbiological contamination. It was established that there were no E. coli, S. Aureus and Salmonella bacteria in them, which fulfills the requirements of TR TS 021/2011.

4. Conclusion
As a result of the carried-out researches, there were developed formulations and technologies of bakery products based on dried and liquid sourdoughs of spontaneous fermentation supplemented with demineralized dried whey, oat-flakes, infrared-dried carrot powder and fine eggshell powder.

It is determined experimentally that bakery products based on the dried sourdough have got higher sensory and physico-chemical characteristics than bakery products based on the liquid sourdough. Therefore, after comparing dried and liquid sourdoughs, it can be concluded that dried sourdough allows to exclude its obtaining process, intensify and simplify the dough preparing process, which requires exact temperature and acidity values. This is because dried sourdough is a ready product, and it is introduced into the dough in dried state. In comparison with yeast, dried sourdough helps bakery products to accumulate such flavoring substances as furfural, acetaldehyde, formaldehyde, methylglyoxal, and others. These substances give the products pronounced taste and aroma, enriched them with vitamins, antioxidants, various macro- and microelements and protect them from microbial spoilage because of antimicrobial substances, which are naturally formed during sourdough ripening.

The results of physico-chemical characteristics evaluation of the developed bakery products show that they can be considered as functional products, because they fulfill more than 15% of daily need in calcium, β-carotene. The products are also enriched with proteins and cellulose because they fulfill more than 10% of daily need in them.

Therefore, the developed products based on dried sourdough have high potential for their implementation into production process as an alternative for traditional bread products. They can be recommended for dietary and gerontological nutrition.

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