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APPLICATION OF SOUR DOUGH IN THE PRODUCTION OF GLUTEN FREE BREAD

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ABSTRACT

Background. Recent epidemiological studies show a high incidence of diseases associated with disturbances in protein metabolism, causing gluten intolerance and consequently the occurrence of celiac disease. Gluten, as a specific protein fraction of wheat, rye, barley and oats, cannot be metabolized in gastrointestinal tract of patients suffering from celiac disease. The prevalence of this disease in economically developed countries of Europe and some others is more than 0.5-1% of entire population. In Russia, celiac disease is considered as rare low incidence disease with occurrence of 1 per 5 to 10 thousand children. The aim of this work was to investigate the possibility of application of new technology for gluten free bread production.
Material and methods. Lactic acid bacteria (LAB) and bifidobacteria (BB) were used as microbial compositions in the gluten-free baking technology. Gluten free bread, made with bacterial and yeast sour dough compositions, was tested for its physical and chemical properties and resistance to spoilage and pathogenic microorganisms during storage.
Results. The preparation of the dough with sour dough containing yeast improved structural properties and taste of the bread. Enrichment by vitamins increased the nutritive value of gluten-free product. Sour doughs increased the acidity and improved the flavor and stability of the experimental bread.
Conclusion. This study indicates that gluten free bread manufactured with sour dough, shows higher sensory and structural-mechanical properties when compared to some control samples. The obtained research results demonstrate the positive influence of bacterial starter cultures to overall quality of gluten free bread, creating the sound foundation for their future application in the bread making industry.

Key words: celiac disease, gluten-free bread, sour dough

INTRODUCTION

The prevalence of celiac disease in the adult population of most countries of the world is estimated as approximately 1:100 – 1:250 or 0.5-1% of the population, which has a genetic predisposition to celiac disease. In Russia in present statistical data on the true prevalence of the disease there, however, some data are close to the European given 1:250 [Oreshko 2008]. However, celiac disease in adults occurs often enough, the disease takes relapsing course and combined with damage to other organs. Population reacts to gluten in Europe accounts for a significant proportion, and deserve, "gluten-free alternative to" not just

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in the medical sense, but in the choice of our daily life and in public catering [García-Manzanares and Lucendo 2011]. Worldwide incidence rises among the able-bodied population, making the disease a socially significant problem.

So it is an actual aim to produce functional food products for patients suffering from celiac disease [Gambuś et al. 2011, Krupa-Kozak et al. 2011, Suliburska et al. 2013]. The most of gluten-free baked goods produced for gluten intolerant individuals, currently present on the market, have a faint flavor; they are also rapidly staling due to high starch content [Kuznetsova et al. 2008]. Our previous investigations covered wide range of gluten-free bakery products – rice bread, rice bread with corn and buckwheat, starch bread with soy and apple powder [Kuznetsova et al. 2001]. Their shelf life is 36 h for unpacked bread and 48 h for the products packed in polymer films. The acidity of gluten-free bread was 0.2 degrees (volume of 1N NaOH, mL, spent for titration of 100 g of product), but in control gluten-containing samples it was no less 0.8 degrees. Low acidity affects not only bread flavor but also reduces the stability of the product to microbial spoilage during storage [Kuznetsova et al. 2007]. It is known that gluten-free bread manufactured with sour dough, has better sensory and structural-mechanical properties when compared to bread without sour dough [Brandt and Gänzle 2006, Elke 2008, Di Cagno et al. 2004]. However, the present research on the influence of LAB and BB to the quality of gluten-free bread hasn't been sufficient. Therefore, the objective of this study was to get a deeper insight into the possible advantages of the application of sour dough in the technology of gluten-free bread production.

MATERIAL AND METHODS

Dough making and microbial strains. The base for gluten-free dough was made with native and extruded corn starch, rice flour, isolated soy protein, sugar, salt and water for reaching humidity of 52%. Lactic acid bacteria (LAB), bifidobacteria (BB) and yeast cultures from collection of State Research Institute of Baking Industry of Russian Academy of Agricultural Sciences, St. Petersburg, Russia were used during bread making as added cultures. Selected LAB strains (*Lactobacillus sanfranciscensis* E-38 and *Lactobacillus plantarum* E-34) were grown on MRS broth [De Man et al. 1960]. *Bifidobacterium bifidum* E-115 was grown on corn-lactose medium GMK-2 (Biokompas-S, Russia) and yeast strains (*Saccharomyces cerevisiae* Y-120, *Saccharomyces cerevisiae* Y-124 and *Candida milleri* Y-128 named early *Saccharomyces minor*) on all-malt wort till 8% of total solids. The pH of media was adjusted to 6.2-7.0. For solid media 15 g of agar was added. LAB and BB were grown at 37°C, and yeasts at 30°C. The cultures of LAB and BB mixed equally were used here as the starter unleavened sour dough. For the development of gluten-free bread biotechnology, two types of sour dough were used. One with LAB and BB with yeast cultures added and the other one without the yeast cultures. Nutrient medium for the renewing of sour dough was prepared by joining the gluten-free rice mixture with water in equilibrium 1:2. Unleavened sour dough (UGFS) was refreshed at a temperature of 34-35°C for 12 h. Leavened gluten-free sour dough (LGFS) in addition to LAB and BB was inoculated with yeast (1:1:1). Nutrient medium for starters was a suspension containing gluten-free mixture and water with humidity 60%. Fermentation temperature was 27-30°C.

Microbial enumeration, acidification ability. Bacteria and yeasts were enumerated at the end of fermentation by plate counts on mMRS and malt wort agar media, respectively. The pH values of sour dough suspension (1 g of sour dough and 9 mL of distilled water) were measured on 0, 6, 12 and 24 h of fermentation (pH-meter 410, Portlab, Russia). The titrated acidity of a solution (10 g of sour dough and 100 mL of distilled water) was measured by pH meter end point titration with 1N solution of NaOH, where 1 mL 1N NaOH is equal to 1 degree of acidity.

Vitamin content. The content of vitamins B_1 and B_2 was determined using fluorescence method (AOAC 957.17, AOAC 970.65). Amount of vitamin B_3 (PP) was determined by colorimetric method (AOAC 961.14).

Shelf life control. Bread samples, prepared both with GFS and yeast (LGFS) or without yeast (UGFS) and control samples (without GFS), were stored at common room conditions (humidity 70-75%, temperature 22-24°C), or in conditions provoking development of spoilage microorganisms (humidity 85-95%, temperature 38°C) for 144 h. During this period the growth of molds and development of rope spoilage were monitored by detection of smell and stickiness occurrence time, as well as mold development time.

RESULTS AND DISCUSSION

The results have shown that the highest acidity levels (13.8-18.5 degrees) observed in UGFS, were recorded in nutrient medium with gluten-free mixture with water. The recorded values of titrated acidity in UGFS, with a partially or fully scalded gluten-free mixture, were 9.2-14.5 deg. The volumes of these sour doughs (all gluten-free mixture or 27-33% added in the scalded form) were rising during fermentation period up to 150-200%. Microbiological analysis of GFS showed active development of LAB. After 12 h fermentation, the acidity of sour dough was 11.5-14.5 deg, and the ratio of yeast cells and bacteria varied in range from 1:3 to 1:5.

The use of UGFS (content of gluten-free mixture – 20%) in the preparation of the dough had a positive impact to the quality of gluten-free bread. The titrated acidity of bread increased for 1 deg and improved its sensory characteristics. Upper crust of bread prepared without sour dough, was cracked flat, pale yellow; in contrast with it the upper crust of bread baked with UGFS that became convex and yellowish-brown. The porosity and thickness of pore walls crumb of bread with GFS were average, while the crumb control sample without GFS had larger and thick-walled porosity. Products prepared with GFS acquired a pleasant taste and smell, but control samples had unpleasant flavor with the smell of yeast. Gluten-free bread, cooked on sour dough with yeast had greater specific volume (2.2-2.4 cm^3/g vs. 1.9 cm^3/g in the control samples, that have no yeast) and a better crumb compressibility (35 units of penetrometer vs. 31 units in the control); its acidity was 0.5 deg higher than in control samples. Results of vitamins content in bread with different sour doughs (LGFS and UGFS) are presented in Table 1.

Shown data indicate that in gluten free bread manufactured with use of GFS, the content of vitamins increases from 3.5 (B_3) up to 6 times (B_1, B_2). The vitamin content increases more after addition of bakery yeast in GFS: from 5 (B_3) up to 9 times (B_1, B_2). Quantity of analyzed vitamins in bread with LGFS is higher than in UGFS bread. Thus, the preparation of the dough with GFS containing yeast (LGFS) improves the taste and increases the nutritive value of gluten-free bread due to the enrichment with vitamins. The research also provided the data on the effect of gluten-free bread biotechnology in connection to its microbiological safety during storage (Fig. 1).

Table 1. Content of vitamins in the gluten-free bread, μg/100 g

Vitamins	Vitamins content		
	control bread	bread with UGFS	bread with LGFS
B1	9.85 ±0.073	62.05 ±0.37	80.04 ±0.65
B2	8.03 ±0.050	51.01 ±0.39	74.02 ±0.83
B3	240.0 ±19.50	603.2 ±4.8	1 160.4 ±15.0

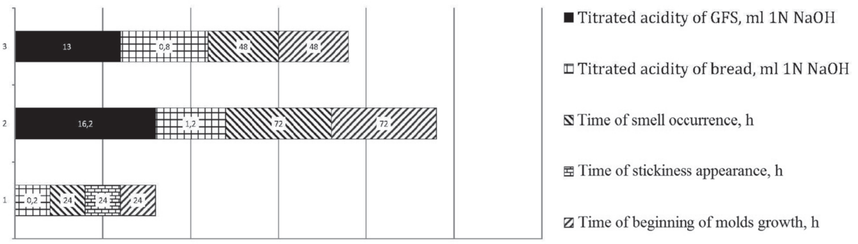

Fig. 1. Influence of dough preparation to the titrated acidity and microbiological purity during storage of gluten-free bread under the following conditions: relative air humidity 85-95%, temperature 38°C; 1 – control sample (without GFS), 2 – UGFS (without yeast), 3 – LGFS (with yeast)

It was revealed that at the appointed conditions the control samples of gluten-free bread (without GFS) were of poorer quality (smell, stickiness) and moldy after 24 hours. In the prototype samples on yeast GFS the signs of rope diseases (smell) and the growth of molds appeared after 48 h, and in bread with GFS without yeast after 72 h. The growth of molds in experimental bread stored at room conditions was detected after 120 h, and in control samples after 96 h. In the bread samples with GFS the signs of rope spoilage were not detected, whereas in the control sample, an extraneous smell was revealed after 96 hours of storage.

CONCLUSION

The sour dough, containing yeast or without them, starter cultures and gluten-free technology for the bread baking were investigated. The manufacturing of gluten-free bread by use of sour dough and gluten-free raw material is proposed. The bread enriched by biological active substances and vitamins as well as the starter cultures was developed. This complex technology enables the production of gluten-free bread having increased biological value and acceptable for persons intolerant to gluten.

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