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THE USE OF ACID DRIED SOURDOUGH STARTER TO IMPROVE SENSORY PROPERTIES AND BREAD`S SHELF LIFE - A REVIEW

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Abstract

Bread is one of the main products of Romanian food industry that is always present in the human daily diet. Current trends are to return to traditional bread making methods using biotechnological processes based on the use of certain bacterial cultures and yeasts. Thus, different types of dough fermentation are used in the bakery industry, such as: acidic substances, pure microbial cultures and microbial cultures developed on a nutritious support (acid sourdough). Lactic acid bacteria (LAB) represent an important group of GRAS (Generally recognized as safe) microorganisms, as they are used industrially mainly in the production of fermented foods and beverages. They have a major advantage, being recognized as safe elements in the food industry. Lactic acid bacteria are also used in starter cultures, thus contributing to the sensory characteristics of finished products. The present study reviews about the use of acid dried sourdough starter and how it can improved the sensory properties and bread`s shelf life.

Key words*: microbial cultures, lactic acid bacteria, biotechnological processes, dough fermentation.*

INTRODUCTION

The current challenges of food industry research are to find alternatives to developing probiotic products other than dairy products, as the latter can cause allergies and lactose intolerance (Lu Zhang et al., 2018; De Prisco and Mauriello, 2016).
In the recent years many probiotic fortified foods have appeared on the market (De Prisco and Mauriello, 2016; Rivera-Espinoza and Gallardo Navarro, 2010) due to the fact that they offer several health benefits, helping to maintain a balance of the intestinal flora and increasing resistance to pathogens (Tripathi M.K. and Giri S.K., 2014).
Of these, bakery products are a very important category, attracting continued interest in research (Pinto et al., 2014; Reid et al., 2007; Soukoulis et al., 2014; Vitaglione et al., 2015; Zhang et al., 2014).
The population is aware of the impact that functional probiotic foods have on health and therefore, there is a fairly high demand for this. Many factors can affect the viability of probiotic organisms during processing and storage. On the other hand, there may be undesirable effects, such as affecting the quality and sensory properties of the finished products. In this sense, by different methods such as: encapsulation, or by adding different protectors and by modifying the processing and storage conditions, it was desired to protect microorganisms (Tripathi M.K. and Giri S.K., 2014).
From ancient times, dough production is considered a biotechnological process, used in the manufacture of bread (Albagli et al., 2021).
Dough is a leavening agent with an important role in baking having as raw material wheat flour, yeast *Saccharomyces cerevisiae*, water (Arendt et al., 2007; Yu et al., 2018) and lactic acid bacteria (Siepmann et al., 2018).
Due to the fermentation of lactic acid bacteria and yeast, the sensory characteristics of the dough, the nutritional value of the bread, but also its taste and aroma change (Chavan et al., 2011; Katina et al., 2006; Tafti et al., 2013). Some researchers (Oshiro et al., 2021; Ganzle et al., 2016) believe that it can also contribute to the shelf life of bakery products.

MATERIALS AND METHODS

This paper is based on recently published articles, accessing Science Direct on the e-nformation platform. The keywords were based on research on lactic fermentation in sourdough, to improve sensory characteristics, such as: taste, smell, texture, shape (appearance) of bread.

RESULTS AND DISCUSSIONS

The introduction of probiotic fortified foods on the market in recent years has been a real success (De Prisco and Mauriello, 2016; Rivera-Espinoza and Gallardo Navarro, 2010).
Bakery products are an area of interest for researchers because they are an important category in the segment of probiotic foods (Pinto et al., 2014; Reid et al., 2007; Soukoulis et al., 2014; Vitaglione et al., 2015; Zhang. et al., 2014).
As an acidifying agent, lactic acid bacteria have an important advantage because they are generally recognized as safe (GRAS) for use in the food industry. LAB contributes to the extension of the shelf life of fermented bakery products, making an important contribution to their organoleptic and nutritional properties (Cucu S.E. and Popa M.E., 2020). They are used in the food industry as initial inoculum in food and beverage production (Zamfir et al., 2014).
In order to improve the quality of the final product in terms of texture, shelf life and flavor, an important step is the fermentation of the dough, largely attributed to the metabolic interaction of microorganisms (Gobbetti et al., 2019). Lactic acid bacteria, along with yeast, are the predominant microflora. Most of those that have been isolated from dough are the genus *Lactobacillus*, and among the yeast species, *Candida* and *Saccharomyces* being the most common (De Vuyst and Neysens, 2005). *Lactobacillus sanfranciscensis* is mainly used in bakery production in the USA and Italy, while *Lactobacillus plantarum* and *Lactobacillus brevis* in Spain (De Vuyst et al., 2014).
The addition of live bacteria should be limited to a minimum number that should be retained in the baked product at the time of consumption (> 6-7 log CFU/g) (Tripathi M.K. and Giri S.K., 2014). Due to the high temperature used during baking, the products can significantly lose viable bacteria and thus become a significant challenge (Zhang et al., 2018). Therefore, it is important to study the bacteria during the baking process, in order to facilitate their development.
According to Chavan and Chavan (2011), most LAB species isolated from dough or used as a starter inoculum, belong to the genera: *Lactobacillus, Pediococcus, Leuconostoc* and *Weisella,* with few exceptions. Among the yeasts, the most common species are: *Candida milleri, Candida holmii, Kazachstania exigua* and *Saccharomyces cerevisiae*. Researching the microbiology of yeast from 1970 to 2013, Huys, Daniel and De Vuyst (2013) reviewed 40 publications revealing six species of yeast often observed in stable dough: *Saccharomyces cerevisiae, Kazachstania exigua, Candida humilis, Pichia kudriavzevii, Torulaspora delbrueckii, Wickerhamomyces anomalus*. They observed the presence of over 60 species of LAB, and most are heterofermentative (*Levilactobacillus brevis - Lactobacillus brevis, Fructilactobacillus sanfranciscensis - Lactobacillus sanfranciscensis, Lactobacillus citreum, Limosilactobacillus reuteri - Lactobacillus reuteri*). There are some optional heterofermentative (*Companilactobacillus alimentarius - Lactobacillus alimentarius, Lacticaseibacillus casei - Lactobacillus casei and Lactiplantibacillus plantarum - Bacillus plantarum*) and homofermentative (*Lactobacillus acidophilus, Lactobacillus delbrueckii* subsp. *delbrueckii and Lactobacillus lactis* subsp. *lactis*).
Lactobacillus plantarum is a Gram-positive bacteria which grows at 10-15°C. *L. plantarum* cells are rod-shaped with rounded ends, usually 3-8 μm long and 0.9-1.2 μm wide. It can be observed microscopically in individual cells, cell pairs or short chains (Corsetti et al., 2016; Hammes and Vogel, 1995; Landete et al., 2010). *L. plantarum* has a relatively large 3.3 Mb genome compared to other *Lactobacillus* spp. species (Darby and Jones, 2017). The length of the genome is influenced by the variety of environmental niches in which *L. plantarum* is found (Landete et al., 2010). *L. plantarum* contributes to the fermentation of

fruits and vegetables. It has a higher tolerance to acid than other lactic acid bacteria (Fleming, 1984; Lu et al., 2003) and represent a potential probiotic (Georgieva, et al., 2009; Janković, 2012; Park and Lim, 2015; Yoon et al., 2006; Zago et al., 2011). The most commonly microbial cultures that are found in doughs belong to *Lactobacilus* sp.*: L. plantarum, L. sanfranciscensis, L. brevis* subsp. *lindneri and L. brevis* (Gobbetti, 1998), but also: *Weisella cibaria* and *Pediococcus pentosaceus* (Iacumin et al., 2009). In the production of bakery, a "starter" strain is used to improve their quality, but also to obtain a variety of standard and quality products (Pepe et al., 2004). *L. plantarum* has many beneficial effects on health due to its probiotic characteristics for fermented products.

Fast fermentation using traditional baking yeast (*Saccharomyces cerevisiae*) is now frequently used. Dough-based fermentation is used worldwide for the production of typical bread dough, pizza, biscuits and more sweet pastries (Reale et al., 2019; Ashaolu and Reale, 2020). Compared to sourdough, the yeast has several advantages, such as: higher productivity, more uniform products, a smaller amount of baking yeast used for a considerable production and lower costs. Comparing the yeast and the sourdough fermentation, the last is more expensive and takes longer; it lasts between 12-24 hours. Maintaining a dough starter consumes time and resources. It has advantages such as: sensory characteristics, digestibility and nutritional attributes compared to bread made from traditional baking yeast dough (Siepmann et al., 2018).

Globally, consumers prefer the products of artisanal bakeries (Albagli et al., 2021) although there are many challenges of drying the dough starter, regarding its microbiological composition. The microbiology of the dough starter is composed of lactic acid bacteria (LAB) and yeast in a ratio of 100: 1 in the usual way (Reale et al., 2019).

The scientific literature on the drying process of the microorganism starter culture is limited, but in many studies, it is found in dry form (Abagli et al., 2021). Drying, either by freeze-drying or by spraying, influences both the aroma and the shelf life of the product. Freeze-drying is done by reducing the activity of water without preheating, but it takes longer than conventional dehydration. Samples need to be frozen quickly, followed by vacuum water removal (Morgan et al., 2006). A freeze-dried starter can be a good replacement for the fresh dough starter used in the production process without pre-fermentation. A reduction in the concentration of flavor components was observed after the lyophilization process of a starter (Kirchhoff, 2000). During the freezing process, water drains from the cells. This causes the formation of ice crystals and an increase in the concentration of intracellular salt, influencing the viability of the cells. A cryoprotectant can be used to prevent cell damage (Stefanello et al., 2019). The cells obtained from the drying process can be recovered by rehydration (Morgan et al., 2006). Cryopreservation increases cell viability using high osmotic pressure, demonstrates Ray et al. (1971). Morgan et al. (2006) demonstrated that rehydration media can play an important role in reconditioning damaged cells by providing essential nutrients and components to damaged cells. Also, the rehydration temperature influences the cells recovery. Thus, a higher number of cells can be obtained by applying a temperature in the range of 15-25°C, than in the range of 35-45°C (Ray et al., 1971). *Saccharomyces cerevisiae* cells rehydrated for 7-16 days under controlled conditions showed greater viability compared to immediate rehydration cells (Poirier et al., 1999).

Meuser, Barber, and Fischer (1995) have shown that lyophilization is a good technique for ensuring cell viability by comparing dry dough with the initial lyophilized dough without cryoprotectant. Thus, they obtained a number of LAB and yeast cells approximately 100 times higher in the case of dry dough compared to the initial lyophilized dough without cryoprotectant, in the first 24 hours of rehydration. Stefanello et al. (2018) used trehalose (as cryoprotectant) for lyophilization of the dough and observed a microbial survival rate 81% more efficient for LAB species than for yeasts, but in terms of cost, trehalose is not the best option.

Stefanello et al., 2019 tested different cryoprotectants, such as: 0.1% peptone water solution, 10% sucrose solution, 5% trehalose solution, 10% skim milk solution and a mixture

of 5% glutamate monohydrate and 10% skimmed milk powder. These were added to the lyophilized species, previously isolated from the dough, of *Lactobacillus fermentum* IAL 4541 and *Wickerhamomyces anomalus* IAL 4533 before freezing, at -80°C (Stefanello et al., 2018). Of the above-mentioned variants, the least effective was sucrose. Caglar et al. (2021) observed a significant difference between the two methods: the powder produced by lyophilization performed a higher number of LAB and yeast than in the case of spray drying. Bread made from spray-dried powder had a larger and a specific volume. At the same time, the increase in the level of dry dough has led to an increase in the hardness of the bread. Dried sourdough acted as a chemical acidifier for the dough. The authors concluded that dry sourdough must be pre-treated, such as rehydrating the powder and refreshing the cells to activate the starter.

Spray drying is a method by which water is removed from a fluid material on contact with the hot air of a drying chamber (Tafti et al., 2013). The process takes place in three phases: atomization, conversion of droplets into particles and collection of particles (separated from the drying medium by a gravitational force and collected) in a tank (Santos et al., 2018).

One of the spray drying applications is mentioned by Tafti et al (2013) regarding the isolation of *L. paralimentarius* from traditional Iranian wheat dough and inoculated (10^8 CFU/g) into a mixture of wheat flour and tap water to make a dough starter. The starter was then spray dried using inlet and outlet air temperatures of 180°C and 90°C, respectively, and the dust was collected from the bottom of the chamber and from the cyclone. The microbial analysis was performed after rehydration with 90 ml of sterile 0.1% peptone water, resulting in a decrease of 10^4 CFU/g of cells, probably due to the high outlet temperature used to obtain a low moisture content (less than 5%, necessary for storage stability) (Tafti et al., 2013).

Using several methods, such as spray drying, freeze drying and oven drying, Ertop et al. (2018) evaluated the physico-chemical properties of bread produced by spontaneous fermentation and the addition of LAB as a starter. Thus, they observed the highest microbial viability, using the method of spray drying, which together with spontaneous fermentation improved the shelf life of bread by slowing down the growth of mold up to 9 days. Bread made with dry starters showed better water retention in the structure, improving moisture, texture and volume compared to the control bread. In addition, according to the authors, the antioxidant activity of the samples of bread baked with dry dough starter was higher compared to the control bread. Due to the metabolism of LAB in the dough, oxidation of lipids or strong antioxidant activity may occur during fermentation, as well as the release of bioactive peptides that are known for their antioxidant effect.

Dry sourdough either by spraying or by freeze-drying method, gives the bread a higher volume, lower elasticity, and a special aroma (Ertop et al., 2018). Other advantages that sourdough has compared to baking yeast dough: the hydrolysis of starch, the higher acidity of the dough and the degradation of gluten. All of that increase the concentration of volatile compounds (the flavor), help to enrich the nutritional value, improve the texture and the digestibility, prolong the shelf life of bread (Siepmann et al., 2018). Volatile compounds depends on the added water content and the microbial species presented in the sourdough (Damiani et al., 1996).

Adding different proportions of dry starter and baking yeast, Tafti, Peighambardoust, Hesari, Bahrami and Bonab (2013) studied the physical and sensory characteristics of bread. They obtained better sensory results than the control when using 9% spray-dried starter.

CONCLUSIONS

Although rapid fermentation with baking yeast is currently used in the manufacture of dough, worldwide trends are shifting to making bread using dough preparation technology, especially using sourdough. Bread made from sourdough fermentation has the advantage of better general sensory characteristics along with digestibility and nutritional attributes compared to bread made from dough with traditional baking yeast.

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