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# The Secrets of Sourdough; A Review of Miraculous Potentials of Sourdough in Bread Shelf Life

Alireza Sadeghi
Department of Food Science and Technology, Faculty of Agriculture, University of Zabol,
P.O. Box 98615-538, Zabol, Iran

**Abstract:** Sourdough is a very complex biological system and an important modern fermentation method of cereal flours and water. The use of sourdough process as a form of leavening is one of the oldest biotechnological processes in food production. Sourdoughs as an ancient way for improve flavour, texture and microbiological shelf life of bread, have been used for thousands of years and are generally regarded as safe. Today, sourdough baking is an alternative to the use of additives. Sourdough fermentation is based on lactic acid and alcoholic fermentation depending on the composition of microflora and fermentation conditions. These factors do not act separately but in an interactive way, adding to the complexity of the system. A common trend of sourdough fermentations is the unique symbiosis of certain hetero and homo fermentative lactic acid bacteria with certain yeasts. Most of the beneficial properties attributed to sourdough are determined by the acidification activity of lactic acid bacteria. Sourdough fermentation creates an optimum pH for the activity of endogenous factors which improve dough properties and texture changes, contributes directly to bread aroma and flavour, increases phytate breakdown, loaf volume and digestibility, delays starch retrogradation, bread firming and staling process, protects bread from mould and bacterial spoilage and probably enhances the human tolerance to gluten. This review focuses on sourdough explanation and its potentials to improve bread shelf life.

**Key words:** Biotechnological process, bakery additive, fermentation conditions, acidification activity, bread shelf life

## INTRODUCTION

Bread is generally viewed as a perishable commodity, while in its many forms is one of the most staple foods consumed by humans, that's shelf life is limited by two main factors, including staling and microbial (fungi spoilage and ropiness) attack (Katina, 2005; Arendt *et al*., 2007).

Preservation of foods by fermentation is a widely practiced and ancient technology. There has been much interest in the potential application of Lactic Acid Bacteria (LAB) as a means of biopreservation that is control of one organism by another (Clarke and Arendt, 2005).

The use of sourdough process as a form of leavening is one of the oldest biotechnological processes in food production that have been used for thousands of years and are generally regarded as safe. Traditional acidic sourdough is ancient way to improve flavour, texture and microbiological shelf life of bread that is used in Mediterranean countries. Today, sourdough baking is an alternative to the use of additives (Katina, 2005).

Sourdough is a very complex biological system and is an important modern fermentation method of cereal flours (especially Rye and Wheat) and water that is fermented with certain microorganisms. A common trend of sourdough fermentations is the unique symbiosis of certain hetero and homo fermentative lactic acid bacteria with certain yeasts. The interaction of yeasts and lactobacilli is important for the metabolic activity of sourdough. Several yeasts are found in sourdoughs but *Saccharomyces cerevisiae* is considered the dominant organism for leavening of bread. The most relevant bacteria isolated from sourdough belong to the genus *Lactobacillus* and the rheology, flavour, nutritional and functional properties of sourdough based baked products greatly rely on the activity of these microorganisms. Lactic acid bacteria usually originate from flour, dough ingredients or the environment (De Vuyst and Neysens, 2005; Gobbetti *et al*., 2005; Paramithiotis *et al*., 2006; Corsetti and Settanni, 2007).

LAB to yeast ratio in sourdoughs is generally 100:1. Whereas in the majority of fermented foods homo fermentative LAB play an important role, hetero fermentative LAB are dominating in sourdough, especially when traditionally prepared. The dominance of obligate hetero fermentative lactobacilli in sourdoughs can be explained mainly by their competitiveness and adaptation to this particular environment. The importance of antagonistic and synergistic interactions between lactobacilli and yeasts are based on the metabolism of carbohydrates and amino acids and the production of carbon dioxide (Gobbetti, 1998; Clarke *et al*., 2004; Corsetti *et al*., 2007).

Commercial sourdough processes do not rely on fortuitous flora but on the use of commercial starter cultures. Inoculation of the sourdough with starters increases the number of lactic acid bacteria to $10^7$-$10^8$ cfu $g^{-1}$, which gives little possibility for growth of contaminating organisms. The range of commercial starter culture includes pure starter cultures in powder form and starter cultures that are active sourdoughs. Sourdough fermentation is based on lactic acid and alcoholic fermentation depending on the composition of microflora and fermentation conditions (fermentation temperature, time and dough yield). These factors do not act separately but in an interactive way, adding to the complexity of the system (Thiele, 2003; Katina, 2005).

Sourdoughs have been classified into three types, based on the kind of technology applied for their production, as used in artisan and industrial processes. Type I sourdoughs are manufactured by traditional techniques and are characterized by continuous (daily) propagation to keep the microorganisms in an active metabolic state. Generally, three stage fermentation processes are used at a temperature below 30°C. Type II sourdoughs involve a less time consuming, one stage fermentation process at a temperature exceeding 30°C and are used mostly in industrial processes. Sourdoughs are fermented for a long period (up to 5 days) with a high dough yield (semi liquid preparation) and microorganisms show restricted metabolic activity. Sourdoughs serve mainly as dough acidifiers and flavouring agents. Type III sourdoughs are manufactured by sourdough fermentation with subsequent water evaporation leading to dried preparations which are used as acidifier supplements and aroma carriers (Meignen *et al*., 2001; De Vuyst and Neysens, 2005; Gaggiano *et al*., 2007).

Sourdough fermentations enhance dough properties; improve volume, texture, flavour, retard the staling process of bread and protect bread from mould and bacterial spoilage (Katina *et al*., 2002; De Vuyst and Vancanneyt, 2007).

Some of the reported benefits of sourdough on bread quality may be based on the formation of exopolysaccharides by certain lactic acid bacteria, whereas most of the beneficial properties attributed to sourdough are determined by the acidification activity of lactic acid bacteria. Sourdough LAB fermentation creates an optimum pH for the activity of endogenous factors (Thiele *et al*., 2002) which improves texture changes (Clarke *et al*., 2004), contributes directly to bread flavour, especially, through the synthesis of acetic acid (Gobbetti *et al*., 2005; Ur-Rehman *et al*., 2006), increases the loaf volume (Corsetti *et al*., 1998), delays starch retrogradation and bread firming (Katina, 2005) and inhibits ropiness by spore-forming bacteria (Messens and De Vuyst, 2002; Simsek *et al*., 2006; Mentes *et al*., 2007).

Meanwhile exopolysaccharides produced by sourdough lactic acid bacteria exert effects such as cholesterol lowering, immunomodulating, antitumoral and prebiotic activities. Many new interesting applications for sourdough remain still to be explored, such as the use of prebiotic starter cultures or production of totally new types of bioactive compounds. Furthermore, recent results demonstrate that sourdough fermentation can improve texture and palatability of whole grain, fiber rich or gluten free products, stabilize or increase levels of various bioactive compounds, reduced amounts of harmful compounds, improve mineral and retard starch bioavailability (low glyceamic index products). Pre fermentation of wheat bran with lactic acid bacteria in sourdough bread improved phytate breakdown (up to 90%) and increased magnesium and phosphorus solubility (Katina *et al*., 2005).

There has also been much progress in the development of tools that allow for the selection of key sourdough microorganisms for particular activities such as those concerned with enzymatic, antifungal, antimicrobial, nutritional and additive replacement aspects.

## IMPACT OF SOURDOUGH ON BREAD SHELF LIFE

The longer shelf life in bread was possibly associated to the higher water binding capacity of flour, lower crumb firmness, higher loaf volume and bread potentials to prevent microbial contaminations. The sourdough ecosystem has earned special interest due to the benefits gained by its use in bread making. The use of sourdough in bread making contributes to the improvement of bread physical and microbiological shelf life compared to straight doughs.

Many researchers have been studied the effect of sourdough on bread shelf life. For example, Katina (2005) studied the effects of sourdough as a tool for the improving texture and shelf life of wheat bread. She found that wheat bread flavour and texture were effectively modified using optimized sourdough. Katina *et al.* (2006) evaluated the effects of sourdough and enzymes on staling of high fiber wheat bread. They observed least changes in crumb firmness and rigidity of polymers in sourdough bread with enzymes. In contrast to white wheat bread, the starch granules were very much swollen in sourdough bran bread with enzyme mixture. This was hypothesized to be due to the higher water content of bread and degradation of cell wall components leading to altered distribution of water among starch, gluten and bran particles during storage. Corsetti *et al*. (2007) studied the effects of sourdough lactic acid bacteria on bread firmness and staling. Mentioned researchers found that the addition of sourdough to wheat bread reduced crumb firmness and slowed down firming in comparison with breads made with no addition of sourdough. Dal Bello *et al*. (2007) evaluated improvement of the quality and shelf life of wheat bread by fermentation with the antifungal strain *Lactobacillus plantarum*. They reported that sourdoughs and breads produced with this strain showed consistent ability to retard the growth of mould spoilage microorganisms. Author evaluated sourdough effect on Iranian Barbari bread staling (Sadeghi *et al*., 2007) and microbiological shelf life (Sadeghi *et al*., 2008). In our researches, significant effect of sourdough process conditions on Barbari bread staling and microbiological shelf life was clarified. Based on these results, sourdough processes for improve Barbari bread shelf life were designed and regression models for evaluation bread shelf life were exhibited.

Generally, bread shelf life is normally limited by physiochemical deterioration called staling, leading to a hard and crumbly texture and a loss of fresh bake flavour. Bread stales largely as a result of physical changes that occur in the starch-protein matrix of bread crumb. Even though starch retrogradation has been shown to be the primary cause of bread firming, other factors such as the state of proteins and the water content of dough affect the staling rate. Retrogradation is the process by which starch amylopectin reverts to a more ordered state after gelatinization. During sourdough fermentation, lactic acid bacteria produce a number of metabolites which have been shown to have a positive effect on the texture and staling of bread, e.g., organic acids, exopolysaccharides (EPS) and enzymes. EPS produced by LAB have the potential to replace more expensive hydrocolloids used as bread improvers. Recently the ability of certain sourdough originated LAB for producing EPS was demonstrated, many of which are potential anti staling substances. LAB strains possessing proteolytic and amylolytic properties were most effective in delaying staling. Organic acids affect the protein and starch fractions of flour. Additionally, the drop in pH associated with acid production causes an increase in the proteases and amylases activity of the flour, thus leading to a reduction in staling.

The influence of sourdough on bread staling is partly based on improved volume and a positive correlation has been established between softness and volume. The acidity level of sourdough and subsequent bread dough seems to be an important factor. This might be partly explained by the formation of low molecular weight dextrins in acidic conditions, which have been postulated to interfere with the starch retrogradation process. On the other hand, sourdough has been reported to reduce starch hydrolysis by inhibiting endogenous flour alfa amylases. Also, the solubilisation of arabinoxylans during sourdough fermentation might reduce bread staling as pentosans have been postulated to prevent starch-gluten interactions responsible for staling.

It has been noted, however, that the anti staling effect seen for sourdough is strain specific, involving dynamics other than those associated with the degree of acidification. Activities associated with bacterial hydrolysis of starch and the proteolysis of gluten subunits have been proposed by Corsetti *et al*. (1998), Katina (2005), Katina *et al.* (2006) and Sadeghi *et al.* (2007).

With respect to deterioration in the quality of bread during shelf life, mould growth is the most common cause of microbial spoilage. In addition to the economic losses associated with spoilage of this nature, another concern is the possibility that mycotoxins produced by the moulds may cause public health problems. Sourdough capable to control and inhibition of spoilage organisms during fermentation, due to different factors especially low pH value. Positive effects of the use of sourdough on the mould-free shelf life of wheat bread have been reported. Certain sourdough lactic acid bacteria and their components have been shown to have an antifungal effect against various fungal species isolated from flour and bakery products. The same effect has been demonstrated in the context of sourdough wheat breads. The fungi static effect of sourdough addition is attributed to organic acid produced by the LAB strains. Sourdough addition is the most promising procedure to preserve bread from spoilage, since it is in agreement with the consumer demand for natural and additive-free food products.

It is evident that the antifungal phenomenon is not only due to the development of organic acids during the sourdough fermentation process. No correlation between bread shelf life and pH level was reported, but the type and amount of acid present may have an effect on other microstatic agents. The antifungal activities of lactic acid bacteria are complex and that the presence of organic acids may indeed play a role. Other substances contributing to activity of this nature may include reuterin, hydroxyl fatty acids, proteinaceous compounds, cyclic dipeptides, 3-phenyllactic acid, caproic acid, diacetyl and hydrogen peroxide (Messens and De Vuyst, 2002; Clarke and Arendt, 2005; Simsek *et al*., 2006; Dal Bello *et al*., 2007).

Rope spoilage is the most important spoilage of bread after mouldiness. Ropiness in bread is usually caused by *Bacillus* sp. This spoilage is initially noticed as an unpleasant odour, followed by a discoloured, sticky soft bread crumb caused by the breakdown of starch and proteins by microbial amylases and proteases and by the production of extracellular, slimy polysaccharides.

One effective means to limit the germination and growth of rope forming bacteria is to increase acidity, which creates an unfavorable environment for the survival of endospores. Acidity can be increased by adding acidulants or by sourdough fermentation. The most effective acids are propionic acid and acetic acid. Lactic acid has been reported to be less effective. Lactic acid bacteria can also produce antimicrobial compounds (bacteriocins; that are low molecular mass peptides or proteins with a bactericidal or bacteriostatic mode of action) such as nisin, which have the potential to inhibit germination and the growth of *Bacillus* species. The antimicrobial activity of sourdough arises from lactic acid, acetic acid, carbon dioxide, diacetyl, ethanol, hydrogen peroxide and bacteriocins produced by lactic acid bacteria during fermentation. Bacteriocin producing Lactobacillus strains can play a significant role in preventing rope formation in bread by the addition of sourdough prepared by these strains. However, lactic acid bacteria with a capability to produce bacteriocins have not been very effective in sourdough breads and the inhibitory effect of sourdough has been reported to be mainly due to the production of acids (Messens and De Vuyst, 2002; Katina *et al*., 2002; Mentes *et al*., 2007; Sadeghi *et al*., 2008).

The application of sourdough confers many advantages on the shelf life of the baked goods produced. The prospect of increasing shelf life of breads is considerable economic impact and favorable from a consumer's perspective. In this regard, it is to be anticipated that the considerable resources that have been devoted to the biotechnology of lactic acid bacteria over the past number of years will deliver results with respect to this objective.

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