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Functional Perspective on Sourdough Bread

Gizem Kezer[1,a,*]

[1]*Department of Agricultural Biotechnology, Faculty of Agriculture, Kırşehir Ahi Evran University, 40100 Kırşehir, Türkiye*
[*]*Corresponding author*

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A B S T R A C T

In recent years, with the awareness of people, the interest in natural and functional foods has increased. Sourdough is a dough piece in which industrial culture yeasts (*Saccharomyces cerevisiae*), endogenous yeasts, lactic and acetic bacteria from the air and the ingredients used (flour, water, etc.) are active. In sourdough fermentation, yeast and lactic acid bacteria work together to form the natural flora. It has been proven by studies that breads prepared from sourdough have many advantages such as greater volume increase, stronger aroma, better crumb structure and long shelf life. In addition, sourdough fermentation has very important positive effects on human health. Various additives (malt flours, emulsifiers, microbial enzymes, dairy products, soy flour and potato flour) are used to delay the staling of bread. In the production of sourdough bread, high quality and long shelf-life breads can be obtained without the need for these additives. Thus, both natural and additive-free and functional breads are produced. In this review, it is aimed to raise awareness by giving information about the advantages of using sourdough in bread production. In the study, the concept of sourdough was discussed and information was given about the content of bread prepared using sourdough and its benefits on health.

[a] *kezergizem@gmail.com* *http://orcid.org/0000-0003-1530-3664*

Introduction

Bread is produced using flour, water, salt and yeast, and has been in our diet from past to present (Narvhus and Sorhaug, 2012). In addition, continuous researches are carried out on bread, which is a good source of energy. As a result of the studies, it has been determined that bread production has a history of 7800 years (Çiftçi, 2017).

All changes that occur in bread after it comes out of the oven can be defined as staling. When the bread goes stale, there is no change in the composition and nutritional value of the bread. However, it is not evaluated by consumers in terms of sensory properties and therefore bread is wasted. In order to prevent this, various additives (malt flour, microbial enzymes, soy flour, emulsifiers, fats, dairy products, potato flour) are used to improve the physicochemical properties of bread, extend the shelf life and produce quality products. Additives used for purposes such as increasing the acidity of the dough, delaying staling, curing bread faults and diseases, and increasing the volume cause some reservations in consumers (Decock and Cappelle, 2005).

It has been observed that when sourdough is used instead of *Saccharomyces (S.) cerevisiae*, a baker's yeast, during the fermentation of bread dough, superior properties in bread quality and technological value are achieved (Ur Rehman et al., 2006). It has been proven by studies that breads prepared from sourdough have many advantages such as greater volume increase, stronger aroma, better crumb structure and long shelf life (Bircan et al., 2017).

In recent years, the interest in sourdough breads has increased due to the increasing demand for traditional products, consumers' demand for preservative-free, long shelf-life, more nutritious and tastier products (Lotong et al., 2000). Research has focused on sourdough production in order to produce better products with better technological properties, in terms of sensory properties and nutritional quality, and to satisfy consumers who prefer natural production technologies (Decock and Cappelle, 2005).

Sourdough is obtained by fermenting a mixture of wheat or rye flour and water with lactic acid bacteria (LAB) and yeasts (Randazzo et al., 2005). The sourdough process is one of the oldest biotechnological processes used in the fermentation of cereal products (Paramithiotis et al., 2007; Galli et al., 2018). The sourdough method dates back to approximately 5000 years (Vogel et al., 2011).

Bacteria and yeasts work together in sourdough to form the natural flora. The ratio of yeasts to lactic acid bacteria in sourdough is 1:100. Acidification (microbial hydrolysis of starch and proteolytic activity) caused by lactic acid bacteria in sourdough, yeast causes physicochemical changes during the storage of bread (De Vuyst and Neysens, 2005). Sourdough bread, which has natural flora, is preferred due to its suitable volume, strong aroma, good crumb structure and long shelf life (Göçmen, 2001). Sourdough technology is used in different areas from bread production to cake production (Corsetti and Settanni, 2007).

General Composition of Sourdough

In the sourdough method, dough is obtained from spontaneous yeasts and bacteria transmitted from the air and dough components, as well as culture yeasts. A part of the dough separated from the sourdough is used in the fermentation of the next dough (Hansen and Schieberle, 2005). Sourdoughs are divided into 3 groups as Type 1, Type 2 and Type 3 according to their differences in production technology (Minervini et al., 2011).

Traditional sourdough is classified as Type 1 doughs. It is prepared by taking a piece of dough from the previous fermentation and using it. This type of dough is characterized by continuous reproduction of the dough in order to maintain the activity of the microflora (Messens and De Vuyst, 2002; Clarke and Arendt, 2005; Minervini et al., 2010). Generally, the dominant microorganisms are *Lactobacillus (L.) brevis*, *L. paralimentarius*, *L. plantarum*, *L. rossiae* and *L. sanfranciscensis*, which are characterized by their ability to incubate at low temperatures and reproduce continuously (Minervini et al., 2011). Examples of breads prepared with this method are San Francisco sourdough French bread, Trabzon Vakfıkebir bread, panettone and three-stage sourdough rye bread (Meroth et al., 2003; Gerçekaslan et al., 2012).

Type 2 sourdough is fermented at high temperatures with a long fermentation time and high-water content. It is mainly used to acidify and aromatize bread. These are dough starters in semi-fluid form (Minervini et al., 2011). Type II doughs are generally used in industrial processes. Generally, the dominant microorganisms are *L. panis*, *L. pontis*, *L. reuteri*, *L. johnsonii*, *L. sanfranciscensis*, *L. fermentum*. *L. delbrueckii*, *L. acidophilus*, *L. brevis*, *L. amylovorus* and *L. frumentii* (De Vuyst et al., 2002).

Type 3 sourdoughs are considered as dried sourdough consisting of lactic acid bacteria resistant to drying. It is mainly used as flavoring agent (Messens and De Vuyst, 2002; Clarke and Arendt, 2005; Minervini et al., 2010). As with Type II sourdoughs, when making bread from Type III sourdoughs, baker's yeast (*S. cerevisiae*) supplementation is required as a leavening agent (Meroth et al., 2003). Sourdoughs in this group usually contain lactic acid bacteria, which can be resistant to drying and can live in powder form. Examples of these are heterofermentative *Lactobacillus brevis*, facultative heterofermentative *Pediococcus pentosaceus* and *Lactobacillus plantarum* species (De Vuyst and Neysens, 2005).

Sourdough Flora

Sourdough contains a very complex flora. A wide variety of lactic acid bacteria (LAB) and yeast species are detected. It depends on the type of grain used in sourdough production and the fermentation conditions applied. Wheat or rye flour, other ingredients and changes in the technology used in the applied process cause differences in the microbial composition of sourdoughs. It also causes the formation of characteristic features in the final product (De Vuyst et al., 2002). In microbiological studies, more than 50 LAB species belonging to *Lactobacillus* genus and more than 20 yeast species belonging to *Saccharomyces* and *Candida* genus were isolated from the sourdough (Alkay, 2017). While yeasts mainly act as leavening factors, lactic acid bacteria are effective in sensory quality and prolonging the shelf life of the bread (Oral Alver, 2016). Previous studies show that the most common microorganism species in the sourdough flora are *Lactobacillus* species, and besides these, *Leuconostoc*, *Weissella*, *Pediococcus*, *Lactococcus*, *Enterococcus* and *Streptococcus* species (Alkay, 2017).

Table 1. Other microorganisms detected in sourdough in different countries.

Genus of microorganism	Type of microorganism
Lactobacillus spp.	*L. acidophilus, L. delbrueckii, L. farciminis, L. alimentarius, L.casei spp. casei, L.casei spp. rhamnosus, L. viridescens, L. fructivorans, L. kimchii, L. fermentum, L. buchneri, L. vaginalis, L. helveticus, L. curvatus, L. graminis, L. divergens, L. mindensis L. crispatus, L. pontis, L. panis L. frumenti L. johnsonii, L. amylophilus, L. reuteri, L. amylovorus, L. agilis, L. paracasei, L. pentosus, L. acetotolerans, L. paraplantarum, L. sakei, L. lactis, L. rossiae, L. spicheri, L. namurensis, L. coryniformis*
Leuconostoc spp.	*Leu. citreum, Leu. argentinum, Leu. mesenteroides*
Pediococcus spp.	*P. pentosaceus, P. inopinatus P. argentinicus, P.acidilactici, P. halophilus*
Weisella spp.	*W. cibaria, W. paramesenteroides, W. confusa*
Enterococcus spp.	*E. durans, E. faecium, E. hirae*
Candida spp.	*C. boidinii, C. guilliermondii, C. stellata, C. tropicalis, C. holmii, C. krusei, C. milleri*
Pichia spp.	*P. polymorpha, P. saitoi*
Hansenula spp.	*H. anomala, H. subpelliculosa, H. tropicalis*
Saccharomyces spp.	*S. dairensis, S. ellipsoideus, S. inusitatus, S. fructuum, S. exiguus*

The most frequently isolated LAB species are *L. sanfranciscensis*, *L. plantarum* and *L. brevis* (Gobbetti, 1998; Rosenquist and Hansen, 2000; De Vuyst et al., 2002; Pepe et al., 2004, Ur Rehman et al., 2006).

The main typical yeast species in sourdough are *Saccharomyces cerevisiae*, *Kazachstania exigua* and *Candida humilis* (De Vuyst et al., 2014). Most common in stable sourdoughs common yeast species are *S. cerevisiae*, *Candida humilis*, *Pichia kudriavzevii*, *Kazachstania exigua*, *Torulaspora delbrueckii*, *Candida colliculosa*, *Wickerhamomyces anomalus* (Konuralp, 2020).

Additionally, the other microorganisms detected in the sourdough flora in different countries are shown in Table 1 (Hamad et al., 1997; Corsetti et al., 2003; Meroth et al., 2003; Vernocchi et al., 2004; Gül et al., 2005; Randazzo et al., 2005; Ricciardi et al., 2005; Catzeddu et al., 2006; Corsetti et al., 2007; Scheirlinck et al., 2008; Robert et al., 2009; Hütner et al., 2010; Minervini et al., 2011; Ventimiglia et al., 2015).

Benefits of Sourdough

The flora of sourdough varies depending on the flour, dough ingredients and environment used during bread making (Oral Alver, 2016). The use of sourdough instead of commercial yeast during bread production creates more volume, a characteristic aroma and a good texture (Corsetti et al., 2000; Meignen et al., 2001; Clarke et al., 2002; Crowley et al., 2002; Czerny and Schieberle, 2002; Thiele et al., 2002; Gül et al., 2005; Hansen and Schieberle, 2005; Kotancılar et al., 2006; Plessas et al., 2011; Wu et al., 2012; Bircan et al., 2017).

Most of the lactic acid bacteria found in the sourdough flora are probiotic bacteria. For this reason, bread prepared from sourdough becomes a probiotic product (Bircan et al., 2017). It has been determined that lactic acid bacteria produce antifungal compounds such as lactic and acetic acid, carbon dioxide, di-acetyl, hydrogen peroxide, caproic acid, 3-hydroxy fatty acids, phenyl lactic acid, cyclin dipeptides, roterin and fungicines in breads prepared using sourdough (Ekmekçi, 2014). These organic antimicrobial compounds, which are formed during sourdough fermentation, prevent the deterioration of the bread in a short time and extend its shelf life (Katina et al., 2002; Messens and De Vuyst, 2002; Bello et al., 2006; Ventimiglia et al., 2015).

The addition of sourdough delays the enzymatic breakdown of starch in flour. Thus, the water holding capacity of the flour increases (Alkay, 2017). Also, the addition of sourdough reduces the gluten content of the bread (Üstü, 2018). Thus, the kneading time of the dough is shortened (Gül et al., 2005).

Other advantages of bread prepared from sourdoughs are that the glycemic index is very low, beta glucan in the dough is protected from degradation, and that the phytate content is reduced due to the acids formed and the biological usefulness is increased (Bircan et al., 2017).

Lactic acid bacteria found in sourdough produce exopolysaccharide (EPS) in situ. EPS production is one of the main metabolic activities of LAB species in sourdough. EPS plays an important role in probiotic functions by protecting bacterial cells from the external environment. In the food industry, exopolysaccharides are very important due to their viscosity-increasing, stabilizing and emulsifying properties (dextran, xanthan, gellan, pullulan etc.). EPSs positively affect the technological properties of sourdough and sourdough bread (De Vuyst and Degeest, 1999). EPSs have antitumor, antiviral, antioxidant and anti-inflammatory properties. They stimulate and regulate the immune system. Due to the presence of EPS released in the production of bread with sourdough, there is no need to use hydrocolloids that improve the structure and use protective additives (Kaditzky et al., 2008).

Conclusion

Sourdough breads have more volume, characteristic aroma, good texture, probiotic effect, long shelf life, low gluten content and low glycemic index compared to other breads. The use of preservatives is not necessary due to the EPSs and antifungal compounds released in sourdough bread. Thus, the natural product demanded by consumers is obtained. Other positive results are ensuring uniformity in production, saving time, space and labor. As a result, it is also known that prebiotic additives increase in sourdough breads. Sourdough bread is rich in both physicochemical properties and nutritional value compared to regular breads. This makes sourdough breads functional.

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