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Effect of sourdough at different concentrations on quality and shelf life of bread

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ABSTRACT

The objective of this work was to study the effect of sourdough obtained with selected exopolysaccharide (EPS)-producing lactic acid bacteria (LAB) strains on the quality of bread and its shelf life. Two sourdough concentrations were used in order to ascertain the best bread composition. Fresh bread quality was studied by means of microbiological, physical, chemical and mechanical analysis, whereas physical, thermal and mechanical properties were investigated to study the product shelf life. The results showed that dough prepared with 30 g/100 g of sourdough had a negative impact on bread quality properties in the absence of EPS-producing LAB strains, whereas the opposite was observed in the presence of EPS-producing strains: bread samples at 30 g/100 g of sourdough showed higher volume, higher moisture content and better mechanical properties during storage than samples at 20 g/100 g of sourdough. Moreover, 30 g/100 g of sourdough showed a protective effect on bread staling, thus confirming the effect of sourdough concentration and the positive role of EPS on functional properties.

1. Introduction

Baked products are perishable foods that undergo severe physical, physiochemical, sensory and microbial changes during storage (Robertson, 1993). The time-dependent loss in quality of flavour and texture is generally described as bread staling. Crumb firmness significantly increases, crispness of the bread crust decreases, and the bread loaf loses its fragrance, assuming a stale flavour. These complex physical and chemical phenomena are a consequence of a retrogradation of the starch granules gelatinized during baking, an interchange of moisture between the starch and protein constituents of bread, an increase in interaction between the protein fraction and starch, a redistribution of water in bread and a removal of aromatic molecules (Parker & Ring, 2001; Piazza & Masi, 1995; Schiraldi & Fessas, 2001).

The use of sourdough has a long tradition and still plays an important role in bread-making. Sourdough is obtained by spontaneous fermentation of a mixture of flour, water and salt; recent years have seen the use of specific cultures and control of the fermentation process. Its use in baking and its ability to improve the quality and extend the shelf life of bread has been widely described (Arendt, Ryan, & Dal Bello, 2007; Gocmen, Gurbuz, Kumral, Dagdelen, & Sahin, 2007; Katina, Heinio, Autio, & Poutanen, 2006; Martinez-Anaya, 2003). Lactic acid bacteria (LAB) 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/or enzymes. EPS can improve the viscoelastic properties of dough, increase loaf volume, reduce crumb hardness and prolong shelf life (Poutanen, Flander, & Katina, 2009; Tieking & Gänzle, 2005). Moreover, the transformation of amino acids or peptides to aroma compounds contributes substantially to food flavour. In particular, the conversion of glutamate by LAB enables the targeted optimization of food flavour (Gänzle, 2009; Plessas et al., 2011). The *in situ* production of EPS has the advantage of avoiding the use of bread improvers such as expensive hydrocolloids (Arendt et al., 2007; Palomba et al., 2012; Pepe, Ventorino, Cavella, Fagnano, & Brugno, 2013; Tieking, Korakli, Ehrmann, Gänzle, & Vogel, 2003). However, *in situ* production of exopolysaccharides during sourdough fermentation is challenged by simultaneous acidification due to metabolic activities of the bacteria, which may significantly diminish the positive technological impact of EPS (Katina et al., 2009). The formation of alternative products from sucrose like organic acids are of special importance for application of *in situ* produced EPS. In particular, lactate and acetate have previously been identified to significantly affect dough rheology, bread volume and crumb hardness, and may counterbalance the positive effect of EPS (Kaditzky & Vogel, 2008).

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Lacaze, Wick, and Cappelle (2007) have developed a new process to obtain a dextran-rich sourdough in using a specific LAB strain (*Leuconostoc mesenteroides* LMGP-16878) able to produce a sufficient amount of high molecular weigh (HMW) dextran, ensuring a significant impact on bread volume. The sourdough obtained allows improvements in freshness, crumb structure, mouth feel and softness of all kinds of baked goods from wheat-rich dough products to rye sourdough breads. Katina et al. (2009) showed the potential of *Weissella confusa* to produce significant amounts of polymeric dextran and isomaltooligosaccharides in wheat sourdough without strong acidification. Dextran-enriched *W. confusa* sourdoughs showed increased viscosity and improved bread quality. Di Cagno et al. (2006) reported that as shown by carbohydrate consumption, the synthesis of EPS was found from sucrose only. Moreover, compared with a EPS-negative strain (*Lactobacillus sanfranciscensis* SF17), sourdough started with EPS-positive strains (*Weissella cibaria* WC4, *Lactobacillus plantarum* PL9), fermented at 30 °C for 24 h, increased its viscosity, and the resulting bread had higher specific volume and lower firmness. The performance of *L. sanfranciscensis* TMW 1.392 and its levansucrase deletion mutant in wheat dough and their impact on bread quality was studied by Kaditzky, Seitter, Hertel, and Vogel (2008). The authors reported that *in situ* production of EPS was not sufficient to achieve the same positive effects of EPS, as they partially overlapped with effects resulting from enhanced acidification. LAB strains and/or fermentation conditions must be found to maximize *in situ* EPS production while at the same time optimizing acid production to a certain quotient which allows acceptable volume, crumb structure and flavour of breads. Thus, when EPS-producing strains are screened for dough applications, their metabolite pattern, the pH at the end of fermentation and fermentation quotient (the molar ratio of lactate/acetate) should be considered.

In a previous work (Palomba et al., 2012) we showed that sourdough obtained with selected EPS-producing LAB strains after 15 h of fermentation at 30 °C with 5% sucrose resulted in improved viscoelastic properties. Thus, the aim of this work was to study the effect of the sourdough obtained with selected EPS-producing LAB strains on bread quality during shelf life. Microbiological and chemical analysis of sourdough and physical, thermal and mechanical properties of bread were investigated in order to study the evolution of product quality during time. Two sourdough concentrations were studied in order to find the best bread dough composition.

2. Materials and methods

2.1. Sourdough fermentation

Sourdough fermentation was obtained by using two different starters selected on the basis of exopolysaccharide production (Palomba et al., 2012): EPS-positive (EPS+) composed by *Leuconostoc lactis* 95A and *Lactobacillus curvatus* 69B2, and EPS-negative (EPS−) consisting of *L. lactis* 68A and *L. curvatus* 68A2. These LAB strains were previously isolated from sweet baked products (Palomba, Blaiotta, Ventorino, Saccone, & Pepe, 2011) and selected through quantitative analysis on solid media containing sucrose (Palomba et al., 2012). The sourdoughs were prepared by mixing 500 g of wheat flour, 280 g of tap water, 25 g of sucrose and a cell suspension to achieve viable counts of about $5.0 \cdot 10^7$ cfu/g and an incubation period of 15 h at 30 °C.

2.2. Microorganisms, pH and TTA of dough and sourdough

Differential microbial counts of LAB strains were determined on modified Chalmers agar plates (Pepe, Villani, & Coppola, 2001). The pH and acid equivalent were determined by standard methods (AACC, 1975) and total titratable acidity (TTA) was expressed as 0.1 mol equi/L NaOH/10 g of dough.

2.3. Preparation and storage condition of bread

Bread samples were prepared using two different amounts of sourdough: 30 g/100 g of dough (formulation P1), 20 g/100 g of dough (formulation P2). The recipes for the sourdough breads are given in Table 1. Breads were prepared by mixing flour, sugar, salt, yeast (baker yeast, Paneangeli, Italy), sourdough and water. The amount of water to be added was determined so as to have always dough with a consistency of 500 Brabender units (BU). All the ingredient were mixed for 20 min with a spiral mixer (Mod. F100 OEM, Bozzolo (MN), Italy). The dough was divided into 300 g loaves and moulded manually. The loaves were proofed in pans (60 min at 35 °C, RH 70%) and baked in an electric oven (Mod. Modulo, Moretti Forni S.p.a., Pesaro, Italy) at 180 °C for 50 min. After cooling, loaves were characterized and then packed in polymeric bags (PET + COEX EVOH/PE) and stored at 4 °C for 1, 5, 8, 11, 15 days.

2.4. Fresh bread characterization

Bread samples after cooling and before packaging were identified as “fresh bread”. Characterization of fresh bread were performed my means of physical and mechanical analysis.

2.4.1. Physical measurement

Fresh bread volume was determined by applying the rapeseed displacement method. For each sample six measurements were carried out. Colour of crust fresh bread samples was measured with a tristimulus colorimeter (Minolta Chroma Meter model CR 300, Milan, Italy) with a circular measurement area ($D = 8$ mm). The colorimeter was calibrated using a white standard plate ($L = 100$).

Table 1
Sample recipes.

Samples	Recipes									
	Flour (g)	Water (g)	Salt (g)	Yeast (g)	Sugar (g)	Sourdough EPS+ (g)	Sourdough EPS− (g)	Total amount of flour (g)	Total amount of water (g)	Total dough weight
P1+	1000	456	37	20	21	694		1431	697	2228
P1−	1000	380	33	20	18		686	1426	619	2137
P2+	1000	414	34	17	19	406		1252	555	1890
P2−	1000	465	38	18	22		407	1253	607	1950

P1+ = 30 g/100 g of sourdough EPS-positive; P1− = 30 g/100 g of sourdough EPS-negative; P2+ = 20 g/100 g of sourdough EPS-positive; P2− = 20 g/100 g of sourdough EPS-negative.
Total amount of flour in the recipe is calculated as the sum of added flour and flour contained in the sourdough. Total amount of water is calculated as the sum of added water and water contained in the sourdough.