Gluten-free sourdough starter and products

SOURDOUGH FERMENTATION OF GLUTEN-FREE CEREALS MAY IMPROVE THE QUALITY OF BAKERY PRODUCTS MADE FOR PEOPLE SUFFERING FROM CELIAC DISEASE

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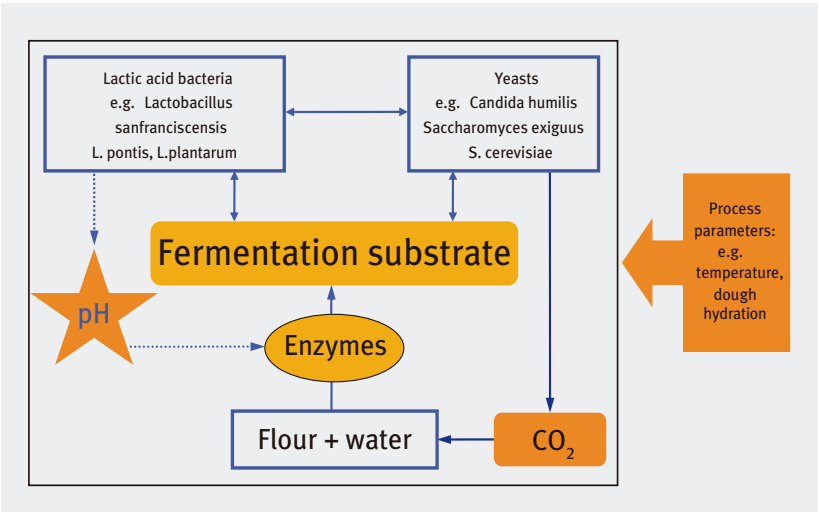
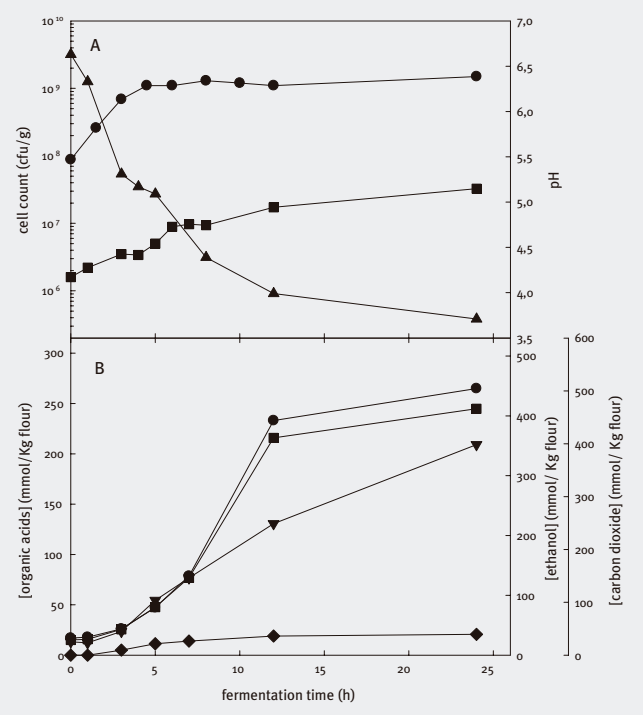
The ingestion of gluten and related proteins causes in genetically susceptible individuals an immune-mediated enteropathy known as celiac or coeliac disease. Epidemiologically studies have shown that 1 in 100 people worldwide suffer from this disease. The only efficient therapy is the avoidance of the gluten containing cereals wheat, rye, spelt and barley in all foods. Oats can be tolerated by most but not all people who are intolerant to gluten. Therefore oats may be allowed on a national level, if they are not contaminated with wheat, rye or barley (Codex alimentarius). Generally, food which contains less than 20 mg/kg of gluten can be labeled as "gluten-free".

Therefore, breads and drinks based on the gluten-free cereals rice, maize, sorghum, millet or the pseudocereals such as quinoa, buckwheat or amaranth were developed. Often, such breads lack the typical texture and flavor. The recipes for such gluten-free breads are more similar to batters than to bread doughs. The gluten-free cereals or pseudocereals are not able to form a gluten network as in wheat, nor do they contain considerable amounts of pentosans as in rye. The addition of hydrocolloids, e.g. guar gum, is generally recommended. Often the crumb of such bread tends to be either sticky or dry and the characteristic flavor of some of the cereals and pseudocereals in use is not to everybody's taste. Over the last few years, enormous breakthroughs have been made regarding the quality of gluten-free breads, but the differences to wheat bread are still vast. Sourdough fermentation may improve such bakery products and indeed, the production of sourdoughs from gluten-free cereals has – especially in African and Asian countries - the same long tradition as in Europe for wheat and rye sourdoughs. For example, injera is an Ethiopian pancake-like bread made from teff flour with the help of sourdough. Similar to this, but made from sorghum is kisra bread from the Sudan. Idli is common on the Indian subcontinent, where there is a great variety of such steamed breads made from rice and beans.

Sourdough fermentation is a complex and dynamic process with permanent changing ecological conditions (Figure 1). The addition of water to flour activates the endogenous enzymes resulting in available carbohydrates and proteins for microorganisms. The growth of lactic acid bacteria and their production of lactic acid leads to a drop in pH, which affects the endogenous enzymes, as their activity depends on the actual pH. For example, the activity of rye amylase is strongly decreased at pH < 4.5 and that is the technologically necessary step of sourdough fermentation in rye processing. Due to the inhibition of amylases, degradation of starch during gelatinization is prevented. Yeasts and heterofermentative lactic acid bacteria produce carbon dioxide which leavens the dough. This complex system can be controlled by the baker by adjusting the process parameters (e.g. temperature, dough yield), which affect the growth of the microorganisms. Thus, the resulting acidity or leavening of a sourdough, respectively, is the result of interactions between the microorganisms and the activity of the cereal enzymes. It is only sourdough organisms, which are well adapted to the specific cereal substrate that will perform well and will result in stable microbial associations (Hammes et al., 2005). Therefore, we have developed a gluten-free stable starter culture composition based on rice. This product is called Reinzuchtsauerteig Rice (active rice sourdough) and contains Lactobacillus fermentum, L. plantarum, L. paracasei, L. paralimentarius, Leuconostoc argentinum and as yeast Saccharomyces pastorianus. A typical process of wholemeal rice sourdough fermentation, started with Reinzuchtsauerteig Rice, and is depicted in Figure 2. Lactic acid



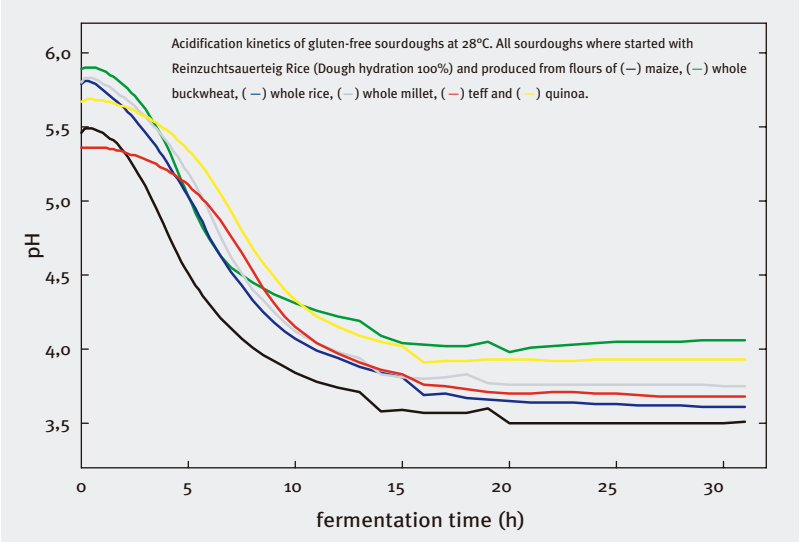
++ figure 1
Interactions during sourdough processing



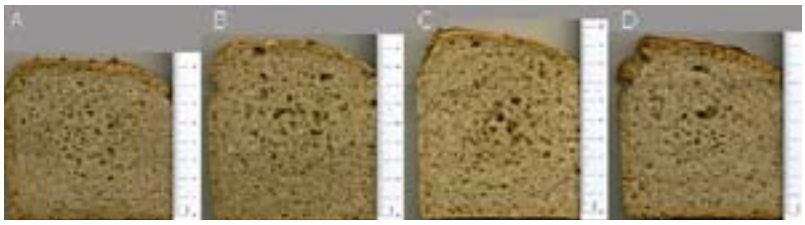
++ figure 2
Kinetics of growth and metabolism during rice sourdough fermentation at 28°C (Dough hydration 100%). A: Cell counts of lactic acid bacteria (●) and yeasts (■), and pH (▲). B: Concentration of lactic acid (◆), acetic acid (■), carbon dioxide (●) and ethanol (●). Concentration of carbon dioxide was calculated according to Brandt et. al., 2004

bacteria and yeast both reach cell counts which are typical for sourdough fermentations. The concentrations of organic acids and the leavening activity are comparable to that obtained from a wheat sourdough (type 550).
The starter cultures worked well in rice, but how will they perform in other gluten-free substrates? Fig. 3. shows the pH development of different sourdoughs (10% starter, dough hydration 100%) and Tab.1 shows the corresponding organic acid concentrations after 24 h fermentation. The starter culture performed well for all gluten-free flours. Interestingly, maize reached only a Total Titratable Acidity (TTA) of 7.3, whereas quinoa resulted in a TTA of 28.8. Acetic acid plays an important role for bread quality (flavor, rope inhibition, shelf life). Its concentration in sourdoughs is mainly affected by the presence of electron acceptors (e.g. Fructose) in the dough (Gänzle, 2006). The molar ratio lactate: acetate (fermentation quotient, FQ) gives a good impression of the availability of such electron acceptors. None of the cereals and pseudocereals supported the acetic acid production in such high concentrations as is usual for rye sourdoughs.

Sourdough fermentation is a laborious and time-consuming process, and therefore a demand for convenient and stable sourdoughs exists. Whereas it is necessary for a starter culture to contain active microorganisms, a shelf-stable sourdough product can be obtained only if lactic acid bacteria and yeasts are brought to a physiologically inactivate state. This can be achieved, for example, by drying of the sourdough. We have compared the performance of rice ▶



++ **figure 3**
Acidification kinetics of gluten-free sourdoughs at 28°C



++ **figure 4**
Breads without (A) or with 24h fermented rice sourdough, started with Reinzuchtsauerteig Rice at 28°C and a dough hydration of 100% (B), with dried rice sourdough (C) or with dried quinoa sourdough (D)

Flour	TTA after 24h (ml 0,1n NaOH/ 10g dough)	Lactic acid (mmol/ Kg flour)	Acetic acid (mmol/ Kg flour)	FQ
Maize flour	7.3	109.9	not present	–
Whole millet flour	14.4	252.4	20.0	12.6
Whole buckwheat flour	11.0	77.3	23.0	3.4
Quinoa flour	28.1	300.8	21.6	13.9
Whole rice flour	12.9	165.4	9.7	17.1
Teff flour	21.3	296.8	19.0	15.6
Rye flour	19.0	240.0	100.0	2.4
wheat flour	16.0	211.9	26.9	7.9

TTA = Total Titratable Acidity, FQ = Fermentation Quotient

++ **table 1**
Characterization of sourdough fermentation

	Control bread	Reinzucht-sauerteig Rice	Dried rice sourdough	Dried quinoa sourdough
Flavor	flat, dominant buckwheat flavor	less acidic and less nutty	less acidic and less nutty	less acidic, nutty
Mouthfeel	chewy and sticky	less chewy and sticky	less chewy and sticky	less chewy and sticky
Resilience	not elastic	poor elasticity	elastic	poor elasticity
pH	6.05	5.08	4.68	5.33
TTA (ml 0,1n NaOH/ 10g bread crumb)	2.3	4.6	4.8	5.1

TTA = Total Titratable Acidity

++ **table 2**
Characterization of gluten free breads

sourdough and dried sourdoughs in a baking experiment. The recipe used consisted of 72% rice flour, 15% buckwheat flour, 5% maize flour, 1.5% shortening, 3.5% egg, 2% baker's yeast and 2% salt at a dough hydration of 84%. Bread A was produced without sourdough. In bread B, 20% of the rice flour was 24 h fermented with Reinzuchtsauerteig Rice at 28 °C (dough hydration 100%). In bread C, 25% of the flour was substituted by dried rice sourdough and in bread D by 15% dried quinoa sourdough. The results are depicted in fig. 4 and tab.2. The bread volume was generally higher in the breads containing sourdough compared to the bread without sourdough. Flavor, mouthfeel and texture were additionally improved by the use of sourdough. Compared to the sourdough breads, the bread without sourdough showed a comparably flat flavor and a dominant buckwheat flavor note. The quinoa sourdough bread had the most intensive nutty flavor. The addition of sourdough obviously decreases the astringent taste of buckwheat. Texture of the breads was improved by sourdoughs as resilience is improved and the breads are less chewy compared to the control bread.

Therefore, the processing of gluten-free cereals by sourdough fermentation is a good tool for optimization of the overall quality of gluten-free breads.

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