Bread technology and sourdough technology

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Bakery industry has known a revolution over the past 150 years. The small artisan bakeries, which were present in every village, made place for high technological bakery industry. Industrial mono-production took over from the high variety bakeries as bread could be produced in a more efficient way. Productivity became the key of success. Different baking technologies were developed to answer better to new market demands. The main consequence of this evolution was a decreased interest for bread flavour through long fermentation processes. A trend has been observed for an increased demand for tastier bread as some artisan bakeries are still producing nowadays or for specialty breads from all over the world. A new business has been created through that demand for companies specialised in the production of stabilised sourdough products. Bakery industry was enabled to provide an answer to the market demand without investment in time, equipment, or extra labour cost.

Introduction

Spontaneous 'sour'dough fermentation is one of the oldest cereal fermentations known in mankind. Its main function was to leaven the dough to produce a more gaseous dough piece and as such a more aerated bread. In a later stage, beer yeast was used for dough leavening (Spicher & Stephan, 1993). Currently, researchers are still further elucidating the wide strain variety and the strain interactions using state-of-the-art analytical methods (Kulp & Lorenz, 2003).

Baking history

In the 19th century, the wheat bread process was a long process, started by slowly mixing the flour and the water to form a gluten network and using long fermentation processes. Due to the slow mixing and the long proofing times, the breads had a very nice aroma. After another bulk proof, the dough was divided into dough pieces and formed by hand. An intermediated proof was necessary to relax the dough for further make up. After the final proofing time and a whole night of work, the breads were baked and sold during daytime.

Automation

The first fermentation step, the bulk proof, was reduced or even excluded during the mechanisation of the bakery. The use of mechanical dividing techniques based on volumetric scaling was not compatible with fermented doughs. To catch up with the loss of flavours, some bakeries developed adapted brew systems. A part of the dough is fermenting during several hours to develop a pleasant aroma. Hereafter sponge, brew or poolish is mixed with the rest of the ingredients into the final dough. With the next step in the evolution, to avoid this complex processing in the bakery, specialised companies supply dried sourdoughs to the bakery industry. Solid phase micro extraction followed by gas chromatography and mass spectroscopy shows clearly that there are more volatile compounds in the sourdough bread compared to the reference bread made in a direct process (Fig. 1). These extra volatile compounds give a broader range of aroma molecules to the sourdough bread compared to similar bread without sourdough. Further automation includes automated liquid of powder dosing systems, continuous or automated batch mixers, continuous belt lines and proofboxes, tunnel ovens, spiral coolers, automated slicing, packaging machines and robot arms who place the final product on pallets. All these systems change the human part from an active to a surveying factor. These industrial bakeries, which produce on an automated direct process, need a good logistic team who can bring the breads to their destination one night after that they are ordered. This method makes it impossible to react with fast deliveries during daytime. This results in daily lost overproductions in order to have enough bread by the end of the day.

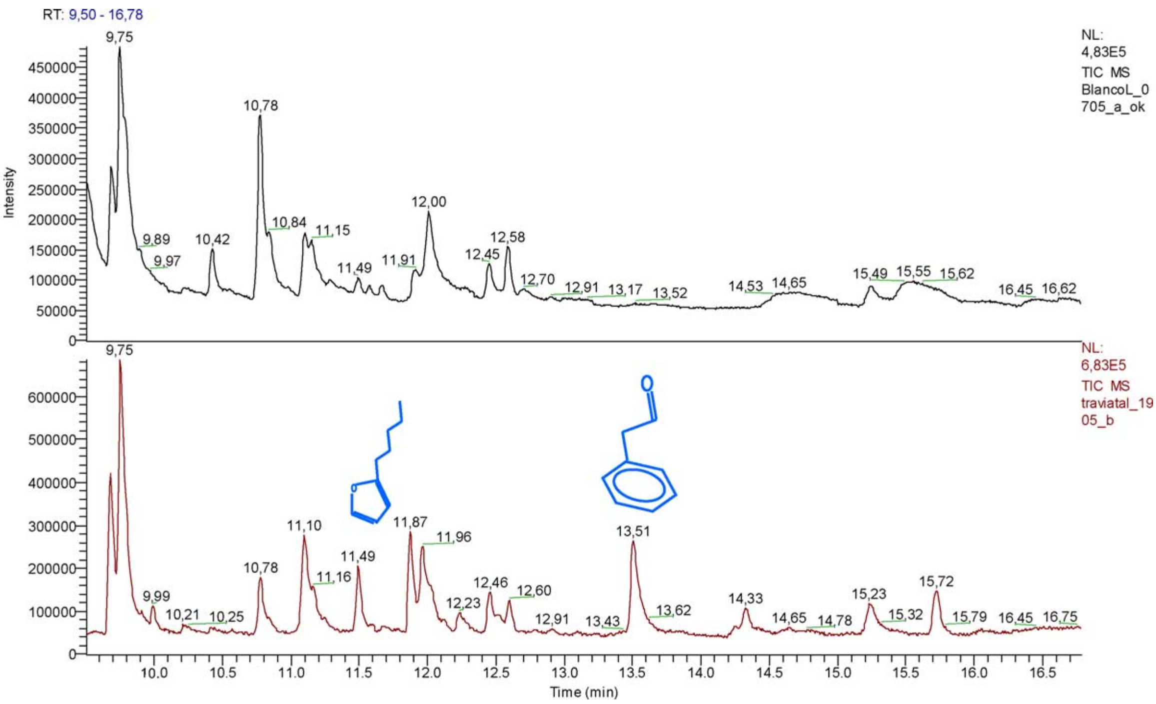

Fig. 1. Comparison between bread without (top) and with (bottom) sourdough. Solid phase micro extraction and gas chromatography.

Nevertheless, the direct process has the advantage of being a very well known process. This technology and the different technologies that are used in the bakery industry are discussed in the next paragraphs (Fig. 2).

Unproofed cooled or frozen dough

Today many bakers cool their dough pieces down to −2 °C the day before and let the proofbox automatically warm up to fermenting temperatures in the early morning. By cooling down the dough, the fermentation speed is reduced to a minimum and allows the baker to reduce the working time during the night by a shift of the work to the daytime. In this evolving market certain segments experience the straight dough process, being a difficult tool to answer the actual trend of serving a wide variety bread range at any time of the day with a continuous fresh end-product. This created the need for flexibility in terms of fresh product (timing) and a quick response to consumer trends (time/variety). Also, the trend of concentration of business (central production–distribution–distance between production site and point of sale) further encouraged the technological evolution within the frozen dough concept. It was back in the late 1970s, industrial bakeries started supplying unfermented frozen dough for bake-off to supermarket chains, retail bakeries, food service and institutional users (Biebaut, 2003). Unfermented frozen dough refers to raw dough pieces who still need to be thawed and proofed, prior to baking. This technology applies to a wide range of layered or laminated (like croissants, Danish) and unlayered (variety breads). Unproofed frozen allowed baking fresh bread on the premises, with excellent organoleptic and textural properties. Improver technology for unproofed frozen dough, which came on the market in the early 1980s, combined with an appropriate processing method to minimize fermentation prior to freezing, allowed to maximize freezer shelf-life. The disadvantage is that more skilled personnel is needed at the bake-off site by replacing the proofing from production to the sales point. The end quality will vary from sales point to sales point. As an advantage, the transport costs are reduced due to the low volumes of the unproofed loafs.

Prefermented frozen dough

At the end of the 1990s, improver technology was introduced for the production of preproofed frozen

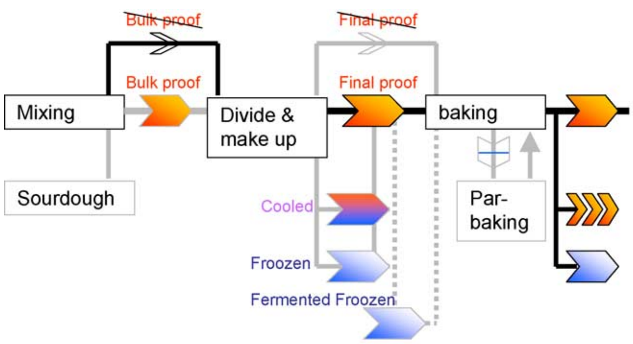

Fig. 2. Different technologies in bakery practice.

dough, both for unlayered and layered systems. The prefermented frozen dough pieces that do no longer require additional proofing prior to baking, fit into this technology. These prefermented frozen dough ferments prior to freezing. The degree of fermentation prior to freezing may vary widely (anywhere between 20 and 100% fermented, compared to a direct fermentation). Freezer-to-oven, turbo, ready-to-bake, frozen-to-bake are marketing concepts fitting within this technology. Most of the time, these dough pieces can go directly from the storage freezer into the oven and supply the bake-off point with freshly baked product within a regular baking time. Layered dough pieces (like croissants, Danish) can directly be transferred from the freezer into the oven. While the same holds for some unlayered items (like ciabattas, seeded and/or decorated bread types), it is highly recommended to defrost most unlayered items prior to baking, especially for items with a plain, undecorated crust (Biebaut, 2003). Prefermented products can be baked in a convection oven or in a deck oven in the case the dough pieces are being thawed prior to baking (having it set at room temperature for about 20 min), but a programmable steam unit is required when products are directly being transferred from freezer to oven at the bake-off point in order to control steam and temperature throughout the baking process. While this technology had already been successful since the early 1990s for layered systems (such as croissants, Danish), it appeared to be much more challenging for unlayered systems like baguettes and variety bread(s). Today, prefermented frozen improver and process technology covers almost the whole bakery range: from white to whole wheat dough, from lean recipes to rich recipes (sweet dough), from 30 to 900 g dough pieces, from round over long to flattened shapes, etc. Decoration and precutting can either be done prior to freezing at the dough production side or prior to baking at the bake-off point. A big advantage is that a fast response is possible with a final result as for a direct process. Compared to par-bake, the volume/transport cost is only half as big but the product is more sensitive to thawing, due to temperature fluctuations during storage and transport.

Ready-to-bake unfermented frozen technology

In the search for convenience, the final fermentation step is even skipped by offering to the bake-off market ready-to-bake frozen products. This ‘zero prefermentation’ process exists in many different formats and varies widely between 0% prefermentation (e.g. Danish pastry without yeast but using baking powder) over 30% relaxation time (yeast-raised *Ready to Bake Croissant* concept without a separate proofing step, but with a 20 min ‘resting period prior to blast freezing’). Already common for croissant and Danish, this technology is now also available for bread and rolls. In the US, some bakers use the technique to bake the unfermented dough after defrosting at 4 °C during the night. Bakeries that made unfermented frozen baguette dough and now want to switch by offering a more convenient, ready-to-bake product can use this technology. For the unfermented dough they did not need the proofbox and now they can make ready-to-bake products with this technology without needing the proofbox. The advantages are the very low transport costs, no thawing needed (for croissants), no proofing and fast answers possible during the day. Disadvantages are longer baking times and the requirement of steam in the oven.

Par-baked bread technology

Baking-off frozen bakery goods and more recently par-baked breads is becoming very popular in supermarkets and small shops. Baking products in bake-off outlets must be an attraction for the consumer looking for high quality taste variations at any time of the day. The most widespread definition for par-baked bread or rolls refers to fully baked products without a crust. Therefore, the meaning of ‘prebaked’ (like in French ‘précuit’ rather than ‘par-baked’) would be a better fit. Most manufacturers prebake their products at lower oven temperatures, while using lots of steam. The major objective of the final (second) bake (at the bake-off point) is to create the crust and to give the par-baked product its distinct flavour, taste profile, and a crispy crust, as the consumer expects. This technology is mainly being used for crusty baked goods such as baguettes along with a wide variety of rolls. Laminated items such as croissants or Danish have not yet been marketed par-baked frozen. In the second part of the 1980s, the concept of par-baked frozen bakery items gained more interest. Improver technology for production of frozen par-baked items was introduced in the early 1990s, improving shelf-life after the second bake while minimizing crust flakiness between the first and second bake. High convenience (limited response time between demand and offer of baked products, no need for skilled labour) made many supermarket in-store bakeries to choose for par-baked frozen bakery products, especially for their crusty items (such as baguettes, rolls and ciabattas). With little to no skilled labour at their bake-off point, the in-store bakeries are able to offer bread, baked on the premises. Up coming is the ‘thaw-and-heat’, during which the baguettes need to be heated up only. The browning can be done during the prebaking phase. The problem that has to be conquered is the flaking of the crust during freezing. Once the bakery has this problem under control, the baguettes can be baked in 5 min at 240 °C. The par-baked technology has as advantage with respect to its short baking time, fast reaction during daytime, easy-to-handle products, no need for steam in the oven, and it is a very well known process. As disadvantage there is a limited shelf-life after the second baking time and high transport costs.

Long shelf-life technology

Last but not the least is controlling the aging of the bread loaf after baking. Different types of packaging in combination with selected ingredients can give the baked bread a shelf-life of weeks and even months at ambient temperature. This process makes it possible to produce through a direct method big batches without the need of throwing away the overproduction at the end of the day, because the breads can be sold the day after or for longer periods. Three aspects are important: avoiding loss of water by the use of a good packaging, controlling process parameters and ingredients to have a slower aging of bread, and holding microbial parameters under control. As first parameter, moisture migration in and around the bread must be avoided. This moisture control starts during baking. A minimal but sufficient baking time gives a longer freshness to the bread. Cooling under conditioned parameters can diminish the water evaporation. Plastic packaging makes the barrier for water migration during long shelf-life. There is also water migration between the dry crust and the humid crumb. Decrusting the bread can eliminate this crumb–crust migration. If there is a filling with a lower water activity than the crumb, the latter will dry out. If the filling has a higher water activity than the crumb, moulds can start to grow. However, phenomena such as firming of the crumb, dry mouth feeling, and crumbling is not only a result of water migration. Some other molecular mechanisms of bread staling are completing the picture. Different enzyme types are known to have an effect on softness/freshness. Some amylases play an important role in staling by the very specific breakdown of starch. From the selective breakdown to destruction, the right balance of action on amylose and amylopectin has to be chosen to obtain the right level of softness, elasticity and stickiness. Maltogenic amylases leave the amylopectin backbone intact due to the partial debranching, which leads to less crystallisation and a softer granule/crumb. The minimal amylose breakdown of maltogenic amylases is resulting in a good elasticity of the crumb. Thermostable amylases result in an intensive breakdown and a sticky crumb. The thermostable amylases also have an intensive breakdown of the amylases resulting in a sticky non-elastic crumb. The long shelf-life also depends on the storage temperature. Frozen breads have a very long shelf-life and are discussed in the next paragraph. Cold temperatures are speeding up the staling of the bread. Better conditions are 15 °C or higher for a minimal staling rate. Also, moulds prefer higher temperatures. To keep the breads longer fresh in bread automates, which allow the baker to sell bread in the street 24 h a day, these automates are heated during the winter period.

Thaw-and-serve

Freezing has been introduced into the bakery trade ever since fully baked products were being frozen and distributed to consumers and business-to-business users in either the frozen or the defrosted state. This technique allowed bakers to increase the shelf-life of their baked products. Commonly known as ‘thaw-and-serve’, these fully baked frozen bakery items offer the highest convenience (fastest response time between demand and offer, no need for skilled labour). Fully baked frozen products only need to be thawed and can either be sold ready-to-eat (thaw-and-serve) or be slightly reheated (food service). Whereas differences in terms of ingredients, additives and processing between unfrozen and frozen fully baked products may seem marginal, frozen fully baked products require special attention for the freezing step. When freezing fully baked products, it is important to prevent the crust from peeling-off from the crumb as the baked products are being kept for significant time in the storage freezer. While rich recipes (with high sugar and/or fat content) such as soft rolls and hamburger buns seem to suffer less from this inconvenience, lean doughs tend to develop this undesirable characteristic as storage time in the freezer increases. A second technology relates to microwave defrosting and heating of frozen bakery items. The offer and variety of microwavable food items has expanded significantly over the past 20 years. One of the main reasons for this success is undoubtedly the speed and convenience at which food can be prepared or reheated in a microwave oven. This has triggered the demand for microwave reheated food items and has led to substantial growth opportunities. Numerous food applications have emerged and the bakery business has been looking seriously at possibilities to take advantage of microwave applications, especially when defrosting and/or re-heating partially or fully baked bakery products. Microwaves open a wide range of opportunities within the area of snacks, quick bites, or eating on the go. Some examples of possible applications are frozen, fully baked and topped pizza’s that can be put straight from the freezer into the microwave oven, frozen hamburger buns, and soft baguette-style breads filled with garlic butter.

Market situation

Regardless the type of technology a bakery is currently using or willing to use, specific or tailor-made conditioning systems and technology allows medium and large wholesale bakeries to produce high quality goods by combining know-how on ingredients and on processing parameters. Additional technologies have appeared on the market in the early 1990s. While the opportunities for microwave baking of (frozen) dough are still being explored, microwaves have entered the baking trade for defrosting and/or reheating purposes. While fully or partially baked products tend to become tough and chewy upon their exposure to microwaves, patented technology has been developed to prevent excessive toughness. The frozen market is large and increasingly growing. Within Europe, the overall frozen market share will gain 4% over a 5 year period (2001–2006), while sales volume for fresh products will progress only slightly. Fresh products will assume a 4% decline in market share versus frozen products by 2006 (Fremaux, 2003). Significant differences exist between individual countries: while production of par-baked frozen bread and rolls appears to be popular in Germany, Spain and the UK, other counties like France tend to focus on unfermented frozen dough. Fully baked frozen products mainly appear in Belgium, The Netherlands, Germany, and the UK. Approximately half of the total European sales volume of layered products (croissants, Danish, cinnamon rolls, etc.) will be distributed through frozen technology by 2006. In North America, most supermarket in-store bakeries use frozen doughs, while the foodservice sector prefers thaw-and-serve products. The latter reflects the need of foodservice operations to prepare large product volumes within relatively short time frames. Almost 90% of all croissants and over 70% of all Danish pastries, baked-off at in-store bakeries in North America come from (un)proofed frozen dough. While the number of in-store bakery units is flattening, the retail sales turnover of these in-store bakeries increases approximately 6% per annum (Gira, 2002).

Back to flavour

Rationalisation and product optimisation leads to a continuous evolution of the bread technology. The new bakery technologies are playing an important role in offering the consumer the advantage of new technologies in combination with the traditional values of bread. Over the past years, bread flavours became very important as consumers increasingly appreciate and demand the flavour and taste of authentic, artisan-style breads. Concepts consisting of liquid and powdered all-natural sponges and sourdoughs allow frozen dough manufacturers to work no-time increasing the freezer shelf-life of their products, while being able to offer an authentic, artisan-style bread flavour. Sourdough fermentation was maintained by some bakeries estimating a return on investment through the flavour properties of the end-product as well as the improved crumb elasticity and better crustiness. Those sourdoughs are mainly started using available substrates and adapted fermentation conditions creating special microenvironments and interesting microbial ecosystems, which are now often the source of in depth research or the basis for industrial companies to produce type III sourdough products as a convenient solution for all above discussed baking technologies.

Technical properties of sourdough

Consistency

Sourdough can vary in its consistency. The sourdough fermentation can be performed as a firm dough or as a liquid suspension of flour in water. This proportion between flour and water is called the dough yield (DY) and is defined as:

$$DY = \frac{(\text{amount of flour} + \text{amount of water}) \times 100}{\text{Amount of flour}}$$

For wheat sourdough this means: a wheat sourdough with DY 160 is a firm dough; a wheat sourdough with DY 200 is a liquid sourdough.

The DY value of a sourdough will significantly influence the flavour profile of the sourdough. The firmer the sourdough (lower DY value) the more acetic acid is produced and the less lactic acid. The flavour of lactic acid is rather mild acid and slow acting, where acetic acid has a sharp acidic taste, which is immediately perceived. The acidification rate is also influenced by the DY of a sourdough. The higher the DY, the faster the acidification will occur, most probably due to the better diffusion of the produced organic acids into the environment (Spicher & Stefan, 1993).

Temperature

A second important parameter is the temperature during the fermentation. The temperature will influence, comparable to the DY, the acidification rate. The temperature has also an influence on the microbial composition of the sourdough. The temperature is even more important if backslopping is used. A part of the previous sourdough is used to inoculate the next fermentation. If temperature is not respected, part of the microflora can be lost over the different sourdough refreshments (Spicher & Stefan, 1993).

Starter cultures

A third parameter is the microflora used for the fermentation. Two main families can be distinguished: the heterofermentative and the homofermentative lactic acid bacteria (LAB). The heterofermentative LAB will produce a mixture of lactic acid and acetic acid. This group of LAB is called the 'aromatic' microflora. The flavour can easily be influenced changing the fermentation temperature as explained above. The homofermentative LAB are fast acidifying and they produce mainly lactic acid. A commercially available sourdough starter commonly consists of mixtures of different LAB groups to assure good acidification and aromatisation.

Substrate

The substrate, mainly flour, used for sourdough fermentation is a fourth parameter influencing significantly the final flavour and acidity of the sourdough.

1. *The ash content*. Flour can be found with different ash content dependent on the extraction rate. The higher the extraction, the higher the ash content will be. The bran fraction contains more minerals and micronutrients

which are important for the growth of LAB. The ash will also influence the buffering capacity of the sourdough system. Due to this buffering capacity, a higher total titratable activity (TTA) can be reached:

$$\text{TTA} = \text{amount of 0.1 N NaOH/10 g of sourdough to reach pH 8.4}$$

This TTA value expresses the total amount of organic acids produced during the sourdough fermentation.

2. *The falling number*. The falling number of the flour is an indicator for the enzymatic activity of the flour. The lower the value the more amylase activity present in the flour. At that moment more free sugars will be available for the microflora (Spicher & Stefan, 1993).

Classification

Sourdoughs are classified into different types (Böcker et al., 1995):

Type I. A sourdough which is restarted using a part of the previous fermentation. These are the traditional sourdoughs.

Type II. An industrial type of sourdough using adapted strains to start a fermentation. This sourdough can be liquid, so it is easy pumpable in an industrial bakery.

Type III. A sourdough which can be dried. This sourdough type is often used by industrial bakeries since the quality is constant and there are no longer end-product variations due to the freshly produced sourdough.

The type III sourdoughs are the most convenient way to introduce authentic bread taste into nowadays high-tech bakery industry.

Type III sourdough

Traditional liquid sourdough is produced in the automised, jacketed tanks, permitting a precise control of the temperature. Most often liquid sourdough is produced with a DY value greater than 200. The DY can vary depending on the final TTA to be reached in the end-product. The acidity in dried sourdough products is concentrated during the evaporation of water. The higher the DY value during fermentation, the higher the TTA will be in the dry product (Spicher & Stefan, 1993). In industry, a lot of type III sourdoughs are available. Different drying techniques are used as well as liquid pasteurisation to achieve microbial stability. Spray drying and drum drying are the most commonly used drying techniques in type III sourdough production.

Spray drying

The liquid sourdough is pulverised in a hot air stream. The water is evaporated while the sourdough droplets are falling down in the hot air. The droplet should not touch the hot walls of the dryer preventing Maillard reactions. The moment the droplet reaches the outlet of the dryer, more than 90% of the water should be evaporated, leaving a dry particle at the end of the process. Due to the presence of evaporating water in the falling droplets, the product itself is cooled down during the process avoiding browning of the powder.

Drum drying

In the drum drying technology, stainless steel cylinders are heated with steam. The surface of the stainless steel cylinders will reach different temperatures dependent on the steam pressure applied. A thin film of product is spread over the cylinder. Almost immediate evaporation occurs. The rest of the residence time of the semi-dry product on the drum will be used to perform Maillard reactions. Dependent on the temperature/time combination, the end-sourdough can be more or less caramelised or toasted. A drum dried type III sourdough will not only add a sourdough flavour to the end-product, but at the same time also some malted, caramelised flavour notes up to a toasted aroma. The crumb can be more or less coloured from slightly a gold to a full brown colour.

Stabilised liquid sourdough

Using the previous stabilisation processes, there is a loss of volatile flavour compounds during the evaporation of the water. A way to prevent this and to achieve more complete flavour properties is to keep the sourdough in a liquid form and to stabilise the sourdough by pasteurisation or by cooling. Most volatile compounds remain present in the product. An advantage for the industrial application is the pumpability of such a product. It can be easily dosed without generating dust. It is very accurate and has a constant quality at any time.

Applications of type III sourdough in modern bakery industry

Rye bread production

Most of rye bread bakers are still preparing a rye sourdough daily. In general, this sourdough process could be called 'Kesselsauer' as it is often made in the same mixing bowls that are used for dough mixing later on. A wide variety of sourdough processes in rye sourdough production are used in the bakeries. The most used one in rye bread production is the '1-Stufen Sauer', which is a firm rye sourdough made in one step using a piece of the previous production.

Rye flour does not contain gluten, as known in wheat flour. During the mixing of a rye dough, no gluten network is build. Pentosans are playing a key role during the rye dough development. Water absorption by the pentosans is increased due to the acidification step. This water can then be released during the baking towards the starch resulting in softer and moister bread. A second function of the sourdough in rye bread production is to decrease the amylase activity present in the rye flour. On the contrary to the amylases present in wheat flour, rye flour amylases are still active when the starch starts to gelatinise during the baking process. When the quality of the rye flour is poor, this amylase activity is so high that the crumb is completely hydrolysed during baking. By decreasing the pH of the dough by a sourdough fermentation, amylases are inhibited. Further advantages are of course an improved flavour, an improved microbial shelf-life, crumb softness, etc. As a general rule for proper acidification of a rye bread, one third of the rye flour should be added through a sourdough. Very high amounts of sourdough have to be produced in the bakery. This means that at least one third to half of all doughs prepared in the bakery has to stay in a mixing bowl for at least 8–12 h, which is a significant loss of valuable time. In this case, a stabilised liquid rye sourdough can be a convenient solution for the rye bakers, since its sourdough is converted into a stable sourdough product available in the storage room at a constant quality. The baker can focus on the bread production itself and assure a constant, high quality of the end-product. The flexibility of the bakery increases dramatically, now having its sourdough in stock and ready-to-use whenever it fits into its production planning. Constant quality of its end-product is now its marketing strength. The liberated mixing bowls, normally occupied for sourdough production, can now be re-validated to make specialty bread products with a very high added value (Spicher & Stefan, 1993).

Wheat bread application

Panettone

Panettone is a typical Italian sweet bread, consumed during the Christmas period. As the consumption of panettone is so high at that time, panettone production starts already a few months before each selling period. When the bakers are using a traditional sourdough method, this panettone is still very fresh at the moment of consumption, which is a few months after it has been baked. The secret lies in the sourdough process. Up to seven refreshments of the sourdough are done, each time introducing more sugar to the dough. By this way, the sourdough is adapted to the high sugar level in the end dough (Spicher & Stefan, 1993). A full investigation of the microflora has been done, and the presence of a special sourdough LAB could be elucidated. This sourdough bacterium, *Leuconostoc mesenteroides*, is able to produce an exopolysaccharide, called dextran, based on sucrose. The glucose unit of the sugar is split-off from the fructose by the sucrase activity of the dextransucrase, expressed by *L. mesenteroides*, in the presence of sugar. Glucose is put into a chain, the dextran, and the fructose is liberated into the growth medium and can be further consumed or converted to mannitol. *L. mesenteroides* produces long linear chains with high molecular mass (up to 200 MDa). The branching ($\alpha-1,3$) is less than 5% in this case (Fig. 3). Due to these long linear molecules, a clear structure build up could be proven and is now a patented technology by the company Puratos® (Fig. 4):

$$n\ \text{Sucrose} \xrightarrow[\textit{Leuconostoc mesenteroides}]{} \underset{\text{dextran}}{(\text{glucose})_n} + n\ \text{fructose}$$

The production of a dextran by a particular *L. mesenteroides* strain has been optimised producing around 25% of dextran on dry matter in a sourdough system. This sourdough can then be stabilised by cooling (active), pasteurising, or drying, without loosing the functionality of the dextran molecule. This sourdough product allows the baker to make a panettone in a no-time

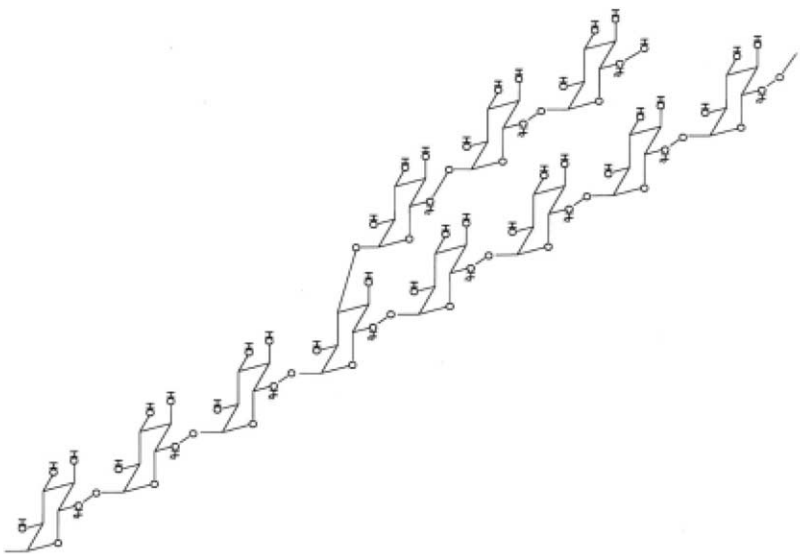

Fig. 3. Dextran molecule: α-1,6 linear backbone with α-1,3 branching.

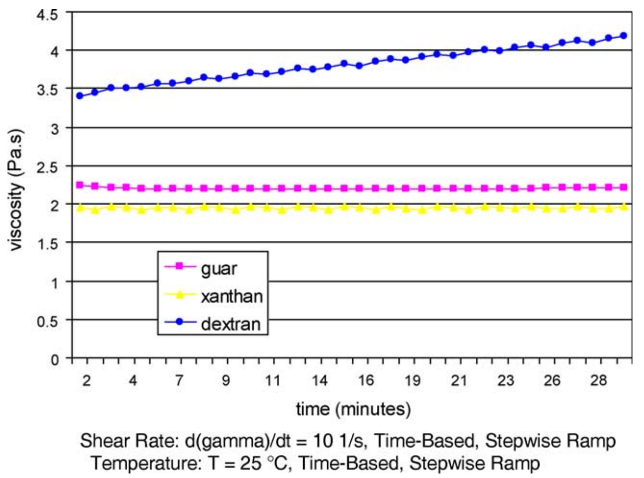

Fig. 4. Texture build up in a dextran solution (Vandamme et al., 1997).

dough method having comparable high quality characteristics as the traditional production. The crumb is very moist over a long period. The crumb structure is more fibrillic with long shape vacuoles. Using such a ready-to-use sourdough product containing the dextran, the baker does not longer have to organise the sourdough production and can produce its traditional bread in state-of-the-art industrial production line (Vandamme et al., 1997).

Other applications were found using this dextran technology. Rye bread and toast bread can be significantly improved by adding dextran to the dough. This shows another big advantage of the type III sourdoughs. Due to their availability, they can now easily be screened and used in new product development.

San Francisco sourdough

San Francisco bread is a traditional bread in the Californian region. It is believed that the strains are imported by French gold diggers and maintained since then. A very typical microflora is present in the real San Francisco sourdough. *Lactobacillus sanfraniscensis* is the predominant LAB. It is a heterofermentative LAB that can grow very well on maltose. This *L. sanfranciscensis* is often in symbiosis with the yeast *Candida milleri*, a maltase-negative yeast which is very adapted to the acid environment. Due to the maltase-negative properties of the yeast strain, the LAB can grow on maltose without competition leaving the free monosugars for the yeast. The way to produce the traditional bread is to ferment the sourdough at very low temperatures during a long time. A sharp acetic acid flavour develops. When the final dough is made, up to 100% of sourdough is used on flour weight and fermented for a second time at low temperature (4 °C) during the night. Small blisters appear on the surface of the dough due to the high acidity. The bread is then baked using a lot of steam and a very crispy reddish crust is obtained showing the typical fish eyes (Spicher & Stefan, 1993). A pasteurised San Francisco sourdough is now available on the market in liquid form to maintain the full flavour, which is typical for this fermentation product. This liquid sourdough is now stable at bakery temperature and can be dosed automatically in the bakery. When the baker adds some more yeast to its no-time-dough method, a San Francisco bread can be made in less than 3 h having most of the typical aspects of the traditional product. The dosage of the stabilised product can be adapted for further product development.

Market

The trend in the market is clearly towards tastier breads. Due to the industrialisation of the bakery business, an electro-mechanical person became the key person assuring the automatic lines to be operational as much as possible. Less skilled bakers became necessary and unschooled persons were hired to do the work. Going back towards traditional fermentation in industry can only be successful if it is linked to an investment in skilled persons. So, the sourdough production, as happened in the past with the production of bakers' yeast, will disappear out of the bakeries, and will be produced by specialised companies, supplying those stabilised sourdough products to bakery industry. No huge and risky investments have to be done in the bakery. The dosing of liquid sourdough products can be easily automised and integrated in the actual production lines. The traditions are maintained by the artisan bakers who believe that the culture of their mother dough assures a superior quality and can be valorised through the better value added for their end-product. This tradition has to be encouraged as they are the source of new ideas and methods which in turn will be used by industry. Besides those artisans, industry can already use nowadays a high variety of stabilised sourdough products leading to a broad range of bread products each differing in flavour without having any trouble to master the different fermentation systems.

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