Traditional Versus Modern Leavening Systems

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ABSTRACT

Breadmaking as we know it, with kneading, leavening, and baking, has existed since the ancient Egyptians. With the introduction of commercial yeast some 150 years ago, much faster processes were suddenly possible, fueling the rise of modern industrial baking in the 20th century. Today's consumer trend is shifting back toward authentic artisan-style breads made using traditional processes. One of the key elements is the use of sourdough with only very small amounts of yeast or no yeast at all, along with extended fermentation times. Several methods exist for starting the fermentation process in a sourdough, from spontaneous fermentation to collecting yeast water or refreshing an existing sourdough. The ecosystem obtained can be very specific, resulting in a unique flavor profile through the breakdown of starch, protein, and mineral fractions in the wheat grain. Process parameters such as time, temperature, and consistency further influence dough and bread characteristics. As a result, the possible combinations are endless, creating a number of challenges for the modern baker who is looking to apply traditional techniques in a larger scale bakery. A variety of systems exist to manage sourdough and long-fermentation processes at different stages of breadmaking. As an alternative, ready-to-use sourdoughs are available and can be used in artisan breadmaking applications.

The Future of Bread Lies in Its Past

Hieroglyphs dating back thousands of years indicate that fermented bread has been made since the time of the ancient Egyptians. Commercial yeast as we know it today was introduced into the bakery only about 150 years ago, so how was bread leavened before this time? Welcome to the world of spontaneous fermentation and sourdoughs. What was once observed with astonishment is now understood to be the work of numerous microorganisms, mainly wild yeasts and lactic acid bacteria. Having been largely replaced by modern commercial yeast systems, these traditional leavening systems are back and bigger than ever. Production of artisan-style breads is booming all over the globe in response to consumers who are seeking authenticity, flavor, and stories far removed from bread with an unhealthy image. Traditional leavening systems offer many benefits. The good news is there are a number of processes and solutions available to integrate these once-common artisan processes into a modern bakery environment.

Sourdough and Artisan-Style Breads

If you ask U.S. consumers what a sourdough bread is like, many will describe the pungent and acidic San Francisco-style sourdough bread. In English the use of the word "sour" in sourdough can be misleading, as the truth is most sourdoughs do not have an acidic flavor. The French call it "*levain*" and in Spanish it carries the beautiful name of "*madre*" (the motherdough)—a term that precisely describes what it does. When added to a freshly made bread dough, the diverse microorganisms in sourdough start the leavening process and develop—many hours later—the unique and complex flavors typical of sourdough breads: fermented, fruity, etc., and yes, to some extent, acidic.

Do all "traditional artisan" breads need to be made with some sort of sourdough preferment? Not necessarily. Yeast too can be used in many different ways, and the same basic principle applies: time (a lot of time) is required to make an outstanding artisan-style bread that is different from mainstream modern bread, which is often made on high-speed lines in less than 90 min using high levels of baker's yeast. The additional time used in artisan baking can be applied at different stages of the process: in preferment, bulk proofing, or a retarded final proof or in combination. There is no clear definition of what an artisan or traditional bread is, but other parameters such as higher water content, stress-free dividing and make up, and baking conditions further contribute to its perceived quality.

Leavening Systems—A Little History

Two main categories of naturally leavened preferments are used in traditional breadmaking: baker's yeast-based preferments (e.g., sponge, poolish [French], biga [Italian], etc.) and sourdough preferment, which is a combination of natural yeasts and bacteria (e.g., sourdough, *levain*, *madre*, etc.). The different categories of preferments result in different flavor profiles—the former being more alcoholic and the latter more complex, with fruity and acidic notes.

Baker's yeast (*Saccharomyces cerevisiae*) as we know it today was discovered in 1857 by Louis Pasteur. Soon afterward, industrial production of this yeast spread around the world. We may take it for granted today, but in the 1800s, this yeast revolutionized the entire baking world. Predictable, easy to use, and fast, it helped boost the industrial production of bread and ensured more consistent quality. Consumers grew used to the more alcoholic taste and liked the fluffy texture of the resulting bread. Traditional methods of breadmaking declined quickly, and with this trend, so too did knowledge of how to make bread using traditional methods. Some of the knowledge survived, however, out of necessity or a passion for breadmaking, and so the sourdough survived, refreshed day after day, generation after generation.

A unique collection of these heritage sourdoughs is stored in the Puratos Sourdough Library in Belgium. Thanks to this library, the research work at different institutions, and the information available in the literature, we now know much more about traditional leavening systems used prior to the industrial yeast era. The main systems are

1) **Spontaneous Fermentation:** A mixture of water and flour is let for a minimum of 2 days, followed by at least 1 week of daily refreshments with flour and water. Gradually, bubbles appear when the microorganisms start to multiply and feed on the sugars in the flour. Probably the oldest

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Puratos Sourdough Library

Nothing demonstrates commitment to traditional fermentation in breadmaking more than the Puratos Sourdough Library. Located within the Center for Bread Flavour, the Sourdough Library has been created to safeguard the sourdough biodiversity of the world and preserve the sourdough heritage and baking knowledge. This is the first of its kind repository in the world.

The idea is simple but important. When a sourdough becomes part of this project, often because of its uniqueness, age, composition, or location, it will be fully characterized, including its microflora. Safe within the library, the sample can then be kept alive and maintained for years to come.

Today this library is home to a unique collection of sourdoughs from bakers across the globe and has contributed to the identification of more than 900 types of yeasts and lactic acid bacteria.

If you would like to learn more about the sourdough library, you can visit it at www.puratossourdoughlibrary.com.

system, this method of leavening depends heavily on the flour used.

2) **Harvested Wild Yeast and Bacteria:** In nature, plants, fruits, and leaves carry microorganisms, wild yeasts in particular. The art of utilizing wild yeast and bacteria involves knowing which ones to harvest and then maintaining them with water and honey or other sugar source until an active "yeast water" is obtained that is capable of fermenting a dough.
3) **Sourdough:** Rather than starting from scratch, as with harvesting, many bakers prefer to refresh their sourdough on a regular basis with flour, water, and other ingredients. Over the years and even generations, many of these sourdoughs and their microorganisms have evolved to contain specific compositions that result in signature bread flavors.
4) **Yeast Obtained from Barm:** Before baker's yeast was widely available, bakers also used yeast obtained from the foam that appears on top of beer brewing tanks, called barm. This foam is heavily loaded with yeast and is an effective source for dough leavening. Historic documents describe how bakers in London were taught to make bread with less barm as it became more scarce, when brewers switched from a top to a bottom fermentation process. The shortage of barm occasionally led to fights among bakers, and eventually, a ban on its use was imposed.

In addition to different types of leavening starters, bakers can also experiment with extra-long fermentation times to enhance the artisan-style characteristics of the bread: utilizing a prefermented sourdough or sponge (usually 3–24 hr), an extended bulk proof (1–2 hr or longer), or a slow, retarded process during the final proofing stage (8–24 hr). Often a combination of all three is used.

	French baguette made with *levain* (wheat or rye flour and sourdough starter; liquid; 15–24 hr at 25–30°C)
	Croissant made with poolish (wheat flour, water, and yeast; soft dough; 4–16 hr at 15–22°C)
	Rye bread made with *sauerteig* (rye flour, water, and starter; dough or liquid; 15–20 hr at 25–30°C; 1 to 3 steps)
	San Francisco sourdough bread (wheat flour, water and starter, containing among other bacteria *Lactobacillus sanfranciensis*; stiff dough; 15–20 hr at 22–25°C)
	Panettone (wheat flour, water, sugar, [egg], and starter; stiff dough; 3 step refresh, each 10–18 hr at 22–25°C)
	Hamburger buns made with sponge (wheat flour, water, and yeast; stiff dough [or liquid]; 3–4 hr at 25°C)

Fig. 1. Examples of breads made using traditional leavening systems.

Traditional leavening systems are still in use today, either in distinct regions, as with German rye breads made with sourdough, or by individual bakers, either craft or industrial, who are convinced of the benefits that sourdough and other traditional fermentation systems can provide. Examples of breads made using traditional leavening systems are illustrated in Figure 1.

Benefits of Using Traditional Leavening Systems Versus a Mainstream Direct Process

The goal of both mainstream and more traditional leavening systems is to raise the dough, resulting in bread with a typical aerated and light crumb. Use of regular commercial yeast at high dosages, in the range of 3 to 5%, fermented at temperatures between 30 and 40°C ensures the dough will rise very quickly, within 1 hr. This is not the case with traditional systems, which require up to 48 hr either with a preferment, as bulk, or a final proof or in combination. This adds complexity to the manufacturing process and requires skilled labor, so why

then are an increasing number of bakers using sourdough and other traditional leavening systems?

- **Flavor:** First and foremost, sourdoughs add a distinctive and pleasant flavor to bread. Many people particularly like fermented foods such as wine, beer, or cheese, and bread is no different. Flavors can vary from alcoholic, to mild, creamy, and buttery, to fruity and acidic. In numerous studies (Puratos Sensobus [mobile sensory analysis lab] data), consumers identify flavor as the number one purchase criteria for bread.
- **Texture:** Similar to flavor, but still very complementary, is the waxy, cohesive, slightly chewy, and more moist texture that is obtained when using long fermentation times and high hydration as opposed to the more foamy texture resulting from faster direct processes. This texture allows for longer chewing without development of gumminess, which in turn develops more saliva and flavors in the mouth.
- **Rheological Properties:** Some bakery applications, such as pizza crusts, baguettes, and croissants, require the dough to be stretched further during make up. The use of preferments (e.g., sponges, poolishes, or sourdoughs) or long resting times creates a final dough that is more relaxed, allowing extension without snapback. This is particularly beneficial on high-volume industrial lines.
- **Acidification:** Obtaining a lower pH is particularly important in the production of rye breads. This enables a gas-retaining dough matrix to be built in the absence of gluten—a matrix based on starch and pentosans. Moreover, low pH inhibits spoilage microorganisms and natural amylases that otherwise would disintegrate the bread structure during baking.
- **Healthy Image:** Although no definite health claims can be made, several studies have confirmed the beneficial effects of long fermentations on the nutrition and health-promoting properties of bread, mainly due to the effect of microorganisms in the dough. Better digestibility is obtained by predigestion of the proteins and starches and lowering of the glycemic index. People who are sensitive to gluten may benefit from this as well. Additionally, minerals such as iron are better absorbed in the gut due to the breakdown of naturally occurring phytic acid.
- **Storytelling:** Breads made with a sourdough often have a strong character. If the sourdough has a story, then so do the breads made with it. Often the story relates to the age of the sourdough or its origin. For example, San Francisco sourdough traces its roots back to French settlers who moved west during the California Gold Rush. Sourdough, and even more so the story behind it, is what many consumers appreciate.

Sourdough—An Ecosystem of Bacteria and Yeasts at Work

In yeast-leavened preferments, such as sponges, poolishes, or bigas, alcoholic yeast fermentation is the dominant biochemical process. There is also some activity from endogenous bacteria present in the flour.

Very different and more complex is the ecosystem within sourdough and its biochemical reactions. Typically, colonies in sourdough consist primarily of a mixture of lactic acid bacteria (around 10^9) and yeasts (around 10^7). Approximately 80% of the bacteria are *Lactobacillus* spp.; the remaining bacteria are *Leuconostoc*, *Pediococcus*, and *Lactoccoccus* spp., as well as others. The scenario for yeasts is similar. In addition to the dominant baker's yeast, *S. cerevisiae*, the yeast colonies also include *Candida*, *Kazachstania*, and *Torulaspora* spp., among others. The proportion of yeasts and bacteria and their composition depends largely on the origin of the sourdough; however, the baker's hands, flour used, storage conditions, etc. also play roles in shaping the colony that will create the signature flavor of a baker's sourdough bread.

Several fermentation pathways occur when flour, water, and a starter colony are blended. Interestingly, bacteria and yeasts work very closely together.

Carbohydrate Fermentation. Carbohydrates such as starch and free sugars are very quickly partially fermented by yeasts and converted into ethanol, CO_2, and aromatic compounds. Almost simultaneously, but at a slower speed, lactic acid bacteria metabolize carbohydrates into lactic and acetic acids and CO_2 gas. In stable sourdoughs, there is no direct competition between yeasts and bacteria because each metabolizes different sugars. The resulting gas raises the dough, while at the same time the pH drops and acidity increases. Depending on the fermentation temperature and cultures used, a pH value of around 3.5 can be reached after a minimum of 15 hr, after which further slow acidification occurs until full stabilization of the bacteria and yeast in the dough.

Protein Degradation. During the long hours of fermentation, bacteria break down some of the proteins, mainly gluten, into smaller amino acids. This allows the number of bacteria to multiply. The yeasts present in sourdoughs further digest these amino acids, while producing superior alcohols and aldehyde components that are responsible for the complex fruity and flowery notes in sourdough breads.

Because sourdoughs are complex living systems, the results obtained depend largely on a number of formulation and process variables. The substrate (flour) is key. With rye flour, more fruity notes are obtained compared with wheat flour. A higher ash content creates sourdoughs with higher acidity due to the buffering capacity of the bran. Damaged starch, proteins, and germ further influence fermentation and its by-products. In addition, the level of water influences the acid profile: stiffer doughs tend to result in a more vinegar-like flavor. Furthermore, the temperature is critically important: lower temperatures (20–25°C) are more favorable for yeast growth, while temperatures around 30–35°C are more favorable for lactic acid bacteria growth.

Traditional Leavening Systems in Modern Bakeries—Hurdles and Practical Solutions

Traditional leavening systems require time—lots of it. This means that to use traditional systems a bakery needs to create a large, temperature-controlled space for storage and handling. For bulk proofing, after mixing the dough can be placed in bowls and set aside or it can be placed in a container that can be stored through the use of automated systems. The same is true for the final proofing. The crumb texture benefits from a slow, extended proof (a minimum of 6 hr), ideally overnight at around 10°C, especially if no bulk proof is performed. Large retarding proof boxes can be used—first in, first out, on racks or in a continuous system. The cost, however, can be significant.

Sourdough production is a different story. Making sourdough at home is not all that complicated; social media is full of home bakers proudly sharing their breads and stories

of their sourdough. An interesting source is the website thequestforsourdough.com, which features more than 1,100 sourdoughs from all over the world.

The sourdough process becomes much more complex when it is used to make quality sourdough bread consistently in a large-scale production environment. The challenges, in addition to space and capacity, include finding the skilled labor needed to manage food safety concerns and to ensure enough product with a constant quality is produced day after day. Several options exist: bakeries can either make the sourdough in-house or buy it from a third party, customized and ready to use. The most common method of making sourdough involves use of a high-shear mixing device and a fermentation tank, followed by cooling and storage. A second smaller tank may be required to prepare the starter, using previous sourdough or pure starter cultures. Typical fermentation times range from 15 to 24 hr. Full control of the incoming raw materials, time, temperature, and cleaning, as well as a stable and dependable starter, are prerequisites for successful and consistent sourdough production.

As an alternative, some companies (e.g., Puratos) offer ready-to-use live sourdoughs and can even customize these on demand. Such sourdoughs are extremely convenient to use and solve most of the challenges associated with space, labor, food safety, and consistency. Combinations of these two options exist as well, allowing bakeries to complement the flavor profile of their in-house sourdough with ready-to-use sourdoughs made with different microorganisms and flours.

Traditional Leavening: Old-Style Processes for Modern Bakery Trends

There is no doubt that we are experiencing a renaissance of artisan-style breads around the world. Just open any life-style magazine and chances are you will come across an article featuring traditional sourdough or hipster bakeries in London and New York. Beautiful books explain the art and science of breadmaking. Restaurants have diversified the breads they offer, just as they did for wine and beer many years ago. Following the molecular cooking trend and the scaremongering concerning breads loaded with bad carbs, gluten, GMOs, and additives, consumers are rediscovering traditional breadmaking as it has existed for many centuries: flour, water, salt, and…passion. They are looking for artisan-style breads, seeking their authentic looks and pleasant flavors and textures. Sales of such breads are soaring, whether they are sold fresh in artisan shops, prepared as a sandwich, or packaged and sold in the deli aisle of the grocery store.

Bakers have a multitude of ways they can respond to this trend. The form of the perfect artisan-style bread is not defined, so the combinations that can be used to make it are endless. Solutions exist both for smaller and industrial-scale manufacturers—it is simply a matter of choosing the right one and grasping the opportunity.

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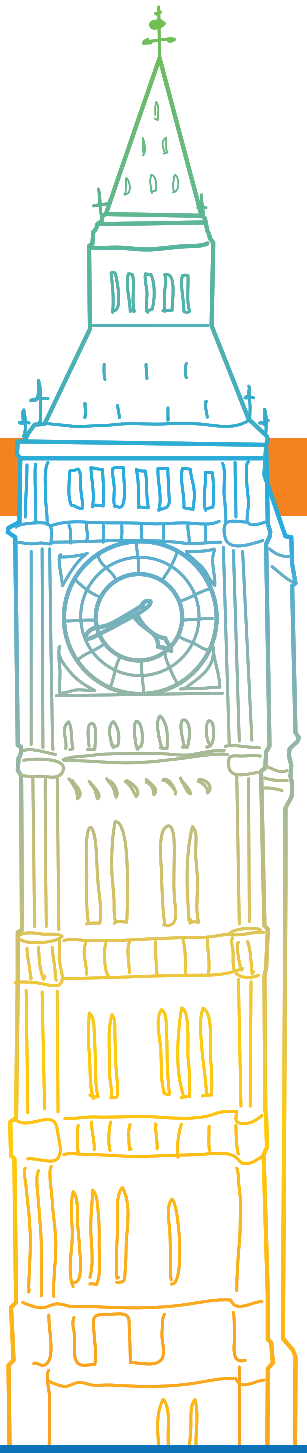

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