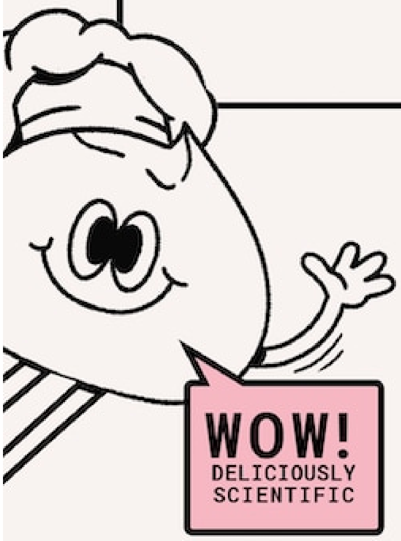
HENDRIK KLEINWÄCHTER

The creator of the infamous youtube channel THE BREAD CODE

THE SOURDOUGH FRAMEWORK

YES

YES!



YES!!!

WARNING: You'll bake bread so insanely good, you'll never be able to enjoy the one your local bakery has to offer

the BIBLE FOR SOUR DOUGH NERDS

The Sourdough Framework

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Hendrik Kleinwächter

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Preface

If there is one food Germany is known for, it is probably bread. There are thousands of varieties in Germany, and making it has been an integral part of our culture.

My bread journey began during childhood. My mother, being a parent of 3, would always use Saturdays to bake a delicious loaf for the family. It was a white fluffy sandwich bread, and she made it within one to two hour using store-bought yeast. Being a bit more experienced, I now realize it's ideal to wait a little while before cutting into your bread, but back then, we kids couldn't wait. Mom would cut for us a few slices straight from the oven, and we would immediately proceed to pour butter or jam on each slice. Within minutes, one kilogram of flour would be consumed. Bread became an integral part of my weekly food.

I was lucky that my parents could afford a yearly ski trip to Alto Adige in northern Italy. In the small town called Valdaora, we would try new restaurants every year, yet always end up in our favorite pizza place. The pizzas there were incredible. The dough alone was so tasty that we would order just the bread with a bit of olive oil and salt.

Of course, my question would always be, "Mom, can we make this at home, too, please?" So over the years, we became friends with the owners and would receive more and more clues as how to make the perfect pizza dough. There are no secret ingredients inside. It's just flour, water, salt, and a bit of yeast. How can such a simple combination of ingredients create such an incredibly delicious pizza dough? My parents, being creatures of habit, would return every year with us, and every year, my interest would grow. At home, Mom and I attempted to replicate the recipe. We tried baking on a stone and on a steel. We tried adding oil to the dough and herbs to the pizza sauce. We fell into an endless cycle of experiments. However, we never managed to get close to the experience we had while on vacation.

Some years passed, and I eventually began my studies in the small German city of Göttingen. For the first time, I was faced with shopping for my own bread. It was never on my mind to actually start baking it for myself. I would just buy a good loaf while shopping at the supermarket. My favorite variety was a *Schwarzbrot: Korn an Korn*. It's a very dark and hearty rye bread with added berries and sunflower seeds.

Being a little naïve, I'd never before examined the packaging of what I was buying. One day, that changed. I looked at the label and was shocked. The seemingly healthy bread consisted of so many other things aside from flour and water. The black color was not coming from the flour, but from caramelized sugar. The packaging stated it was a sourdough bread, but then why was there additional yeast? I thought that if it was really sourdough, it shouldn't require additional yeast. I soon realized that something was wrong with the bread I was buying. I proceeded to check the other supermarket breads, only to discover that they, too, contained ingredients I'd never heard of. That was the day I lost trust in supermarket bread.

At home, I decided to research the proper way to make bread, and much to my surprise, I learned that the recipes for making pizza and bread were actually quite similar, yet there were also differences. For example, some recipes would call for fresh yeast, while others would call for dry. Diving deep into various online forums and all their many discussions, I became even more confused. I tried using different flours and different brands, all in both organic and non-organic varieties. I realized then that I knew nothing about making bread. Recipes would often contradict each other, leaving me further confused. They seemed like little more than a collection of apparently random steps to follow. The baking instructions and temperatures too were all different...

Meanwhile, having completed my studies, I started work as an engineer. We engineers are faced with many challenges. The compiler or runtime is always screaming at you with errors, and it's your job to figure out how to fix them. It can take hours, sometimes days, just to fix a simple problem. If you want to become a software engineer, you have to develop a certain "never-give-up" attitude.

When writing code, software engineers often need to use a set of pre-made routines. These routines have been written by other engineers and can then be used to ship code faster. This pre-written code is commonly known as *a framework*. In many cases, these frameworks are not built by a single person but by engineers from all around the world, each of whom can help by improving and changing the source code. Frameworks have made many successful businesses possible. In most cases, frameworks do exactly what they claim they do. However, sometimes you are faced with issues you don't understand. In 99.95 % of all software bugs, the developer is the issue. Sometimes, however, the framework has a bug. That is when the developer must dig deeper to see the *what* and the *why* behind what the framework is doing. You will need to read other engineers' source code, and you will be forced to understand *why* things are happening.

Being unhappy with what I was baking, my engineering mindset took over, and I had to do my own deep dive to understand what was going on. Much to my surprise, however, none of the recipes I'd encountered would tell me *why* I should use amount X of water and amount Y of flour, or *why* exactly I should use fresh yeast over dry yeast. Why should I slap my dough while kneading it on the counter? Why is a standmixer better than kneading by hand? Why should I let the dough sit for this long? Why is steaming the dough during baking important? Do I really need to get myself an expensive Dutch oven to bake bread? The problem compounded when I started reading about sourdough. It all sounded like black magic. Why were some sourdoughs made from fruits, while others were made from flour? Why should one recipe use wheat while another used rye or spelt? How often should the sourdough be fed? The questions I had then could have filled 20 pages. I was confused, but I became even more determined to learn how decent bread should be made at home.

The feedback I received from friends helped me to improve with each iteration of homemade bread. Compared to coding, where you sometimes have to wait months for this feedback, bread making is much more direct. Plus, you can eat your successes (and failures!) And, much to my surprise, even those failures started tasting better than most store-bought breads. Eating a homemade bread that takes you hours to make allows you to develop a different relationship with your food, and baking bread from scratch with my bare hands was a welcome change after hours of working on the computer.

I continued learning about the process of fermentation and various techniques of bread making. I approached the topic of sourdough in a manner similar to software, and after years of researching and documenting my progress, I decided it was time to share that progress with the world. When working on software projects, it is important to see their history and how the source code changes over time. This way, you can easily jump back to previous versions. This was the perfect tool for documenting my recipes, because they, too, would change with each subsequent iteration. Much to my surprise, my open source work on sourdough was appreciated by other engineers, and the project became popular on the website GitHub, originally built to share open source software.

Now, when baking great bread, you also need to learn certain techniques. I figured it would be easier to share these techniques in video form. Thus, my YouTube channel was born. I chose the name `The Bread Code` to capture my engineering-oriented approach to bread. It took some time to get it right, but after choosing more engaging thumbnails and titles for the videos I made, the channel started gaining viewers. Finally, three years later, I dedicate two days each week to follow my bread baking passion, while the other three days I continue to work as a software engineer, writing code on a day-to-day basis.

My bread days fill me with both joy and passion. To me, there is nothing better than seeing how many people have made amazing bread thanks to my tips and explanations. The community has continued to grow, spawning many interesting discussions and ideas surrounding the topic of bread making. There is always something new to learn, and I feel that even now I am just barely scratching the surface with what I know and teach. Would you ever have imagined that fruit flies are like bees and are part of the wild yeast's success story? I made a video where I tried to cultivate wild yeast spores coming from fruit flies in order to bake bread. It worked; the bread turned out amazingly well and even tasted good! These kinds of experiments spark my natural interest. Conducting them and seeing how other people share my interest makes me incredibly happy.

The problem with running a YouTube channel is that all the information you see is filtered and then provided to you through an algorithm. I am concerned with how algorithms are shaping modern information, because they tend to put users into certain categories where they will then only see news related to those same fixed categories. A key metric determining visibility of your channel is how many people have clicked on a video after it's been shown, and the content you create is not even shown to every subscriber of your channel. If the algorithm determines the video is not engaging enough, your content starts to decay in YouTube's nirvana. Even if your video goes viral, the algorithm will stop showing it once engagement rates with new users goes down, and older videos fade over time as the decay punishment factor increases. I know, because I have developed similar algorithms myself as a software engineer.

I've since decided to take some time off from the algorithm cycle to work on something more long term and meaningful. My mission has always been to share my knowledge with as many people in the world as possible. That's also why my content has been provided in English rather than German. After discussions with members of the community, I figured that writing a book could help me achieve that goal. Most of the books that exist today are collections of recipes. My idea, however, is to provide you with a deeper foundation of knowledge that you can use to follow other recipes. In software terms, this would be a *bread framework*.

It is my goal for this book to help everyone facing issues with flour, fermentation, baking, and more. It should provide a detailed understanding as to why certain steps are necessary and how to adapt them when things go wrong while making bread. It is my desire for this knowledge to be accessible to everyone around the world, regardless of budget, and as such, I do not want to charge for the book. That's why I've decided to make it open source and have asked the community to support my work with donations. The community's feedback has been amazing so far, and I've already raised much more money than initially expected. The digital version of this book will always remain free. There is also a hardcover version of the book available for purchase. You can read more details here: https://breadco.de/physical-book

In this book, I will try to be as scientific as possible. I in no way claim, however, that it will itself be a work of science. I have conducted several experiments that I will write about here, but to truly call this science, you would probably need to repeat the same experiment a thousand times in a lab environment, which I have not done. I will do my best, however, to provide scientific references where possible and to clearly distinguish between facts and personal opinion.

I hope you have fun reading this and that you learn more about the fascinating world of bread making, and it is my sincere wish that this work provides you with the solid toolchain that I wish I'd had access to when starting my own journey with bread.

Thank you.

Hendrik

Acknowledgments

This book would not have been possible without your help. With all your donations I have been able to focus on finishing this book. Your continuous support allows me to focus on improving this book even more.

Furthermore many of you have contributed and improved the instructions, fixed spelling mistakes and/or provided feedback on the content. Each of you has made this book better.

By providing this book free of charge, we can enable more people around the world to bake delicious sourdough bread at home.

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1

The history of sourdough

We will start this book by briefly talking about the long history of sourdough bread from ancient time, and how people used similar process for other food like beer. The discovery of yeast and how, together with machine development, revolutionized bread making. More recently communities formed around sourdough and home baking, trying to relearn lessons from the past.

The story of sourdough bread begins in prehistoric oceans. These oceans were the birthplace of all life on Earth. To better envision the vast history of our planet, lets create a timeline in one year/365 days. On this scale, January 1 signifies Earth's formation 4.54 billion years ago. Midnight on December 31 is the present. Each day represents roughly 12 million years. This technique simplifies the complexity of time but also renders the extraordinary expanse of our planet's history into a more graspable timeframe. We humans, are in fact a recent addition to our planet, so young that we made our first appearance on the evening of December 31. It seems that humans managed to arrive just in time to join the celebration at the end of the year.

On March 25, the oceans birthed the first single-celled bacteria. In these waters, another single-celled life form, *archaea*, also thrived. These organisms inhabit extreme environments, from boiling vents to icy waters.

Whoever comes first, bacteria or archaea, remains debated. For three months (or approximately 1.1 billion years), these life forms dominated the oceans. Then, on June 25 in a highly unlikely event, an archaeon consumed a bacterium. Instead of digesting it, they formed a symbiotic relationship. This led to the first nucleated organisms, marking an evolutionary milestone. This event lead to the development of plants, fungi and also ultimately humans.

Life stayed aquatic for another three months. On October 4, bacteria first colonized land. By October 15, the first aquatic fungi appeared. They adapted and, by November 24, had colonized land.

By December 3, yeasts emerged on land. This laid groundwork for bread-making. Jump 140 million years to December 14, and dinosaurs arose. Just a couple of days after their

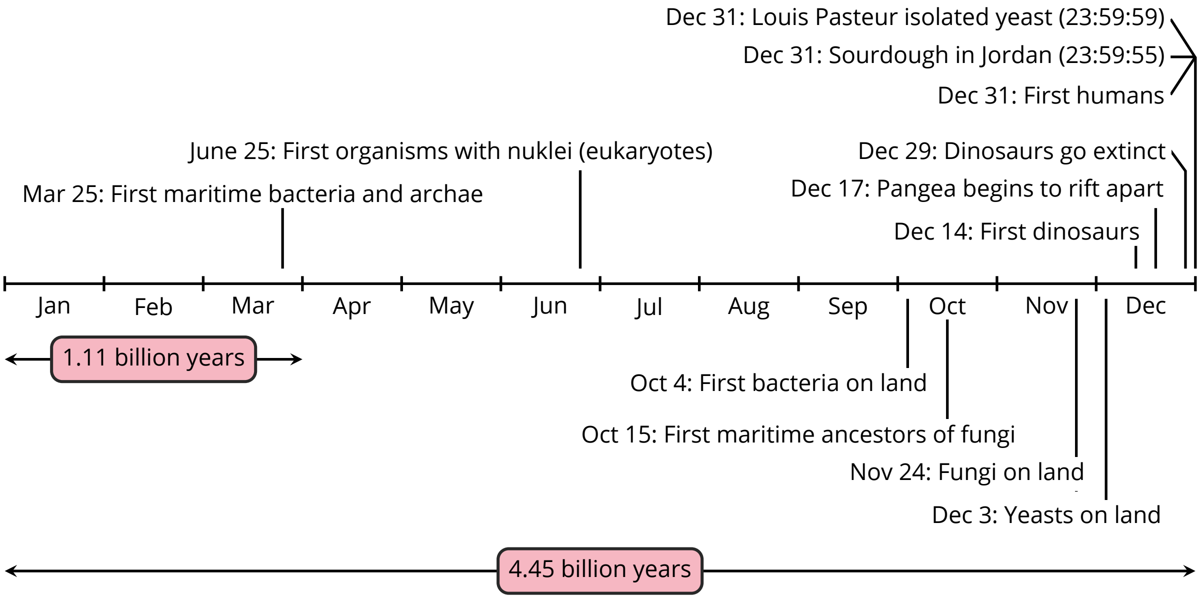


Figure 1.1: Timeline of significant events starting from the first day of Earth's existence, divided into months, and extending to the present day, marked at midnight. This visualization shows the pivotal steps of life and sourdough on earth.

appearance on December 17 the super continent Pangea started to rift apart, reshaping the continents into their current form. The dinosaurs reigned until December 29 when they faced extinction. Another 25 million years later, or our timeline's 2 days after the dinosaur extinction, humans appeared.

A few hours later after the arrival of humans, a more subtle culinary revolution was unfolding. By 12 000 BC, just 5 seconds before our metaphorical midnight, the first sourdough breads were being baked in ancient Jordan. A blink of an eye later, or 4 seconds in our time compression, Pasteur's groundbreaking work with yeasts set the stage for modern bread-making. From the moment this book began to take shape to your current reading, only milliseconds have ticked by [53].

Now delving deeper into the realm of sourdough, it can likely be traced to aforementioned Ancient Jordan [2]. Looking at the earth's timeline sourdough bread can be considered a very recent invention.

The exact origins of fermented bread are, however, unknown. One of the most ancient preserved sourdough breads has been excavated in Switzerland [26].

Another popular story is that a lady in Egypt was making a bread dough close to the Nile river. The lady forgot the dough and at her return a few days later, she noticed that the dough had increased in size and smelled funky. She decided to bake the dough anyway and was rewarded with a much lighter, softer, better tasting bread dough. From that day on she continued to make bread this way [48].

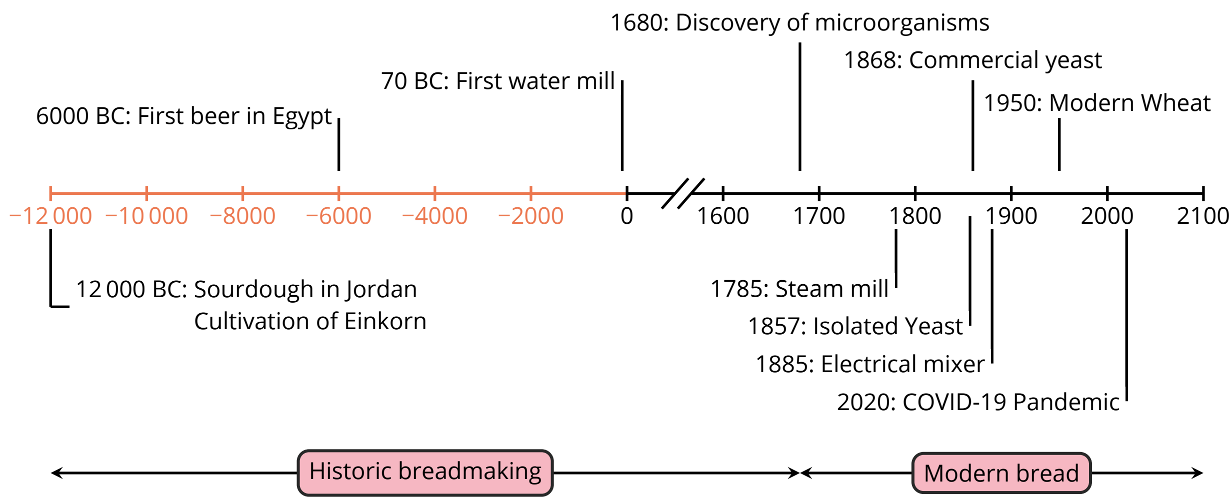


Figure 1.2: Timeline of significant discoveries and events leading to modern sourdough bread.

Little did the people back then know that tiny microorganisms were the reason the bread was better. It is not clear when they started using a bit of the dough from the previous day for the next batch of dough. But by doing so, sourdough bread making—as we know it today—was born: Wild yeast in the flour and in the air, with bacteria starting to decompose the flour-water mixture. The yeast makes the dough fluffy, and the bacteria primarily creates acidity. The different microorganisms work in a symbiotic relationship. Humans appreciated the enhanced airy structure and slight acidity of the dough. Furthermore, the shelf life of such bread was extended due to the increased acidity.

Quickly, similar processes were discovered when brewing beer or making wine. A small tiny batch of the previous production would be used for the next production. In this way, humans created modern bread yeasts, wine yeasts, and beer yeasts [40].

Over time with each batch, the yeasts and bacteria would become better at consuming whatever they were thrown at. By feeding your sourdough starter, you are selectively breeding microorganisms that are good at eating your flour. With each iteration, your sourdough knows how to better ferment the flour at hand. This is also the reason[1] why more mature sourdough starters sometimes tend to leaven doughs faster [25]. The sourdough in itself is a symbiotic relationship, but the sourdough also adapted to humans and formed a symbiotic relationship with us. For food and water, we are rewarded with delicious bread. In exchange, we shelter and protect the sourdough. Spores from the starter are spread through aerial contamination or insects like fruit flies. This allows the sourdough starter to spread its spores even further all around the world.

[1]It is crazy if you think about it. People have been using this process despite not knowing what was going on for thousands of years!

Figure 1.3: An ancient Einkorn flatbread. Note the dense crumb structure.

Evidence suggests early grain grinding in northern Australia around 60 000 BC, notably at the Madjedbebe rock shelter in Arnhem Land [46]. However, a more significant advancement occurred later, as documented by the ancient Greek geographer Strabo in 71 BC. Strabo's writings described the first water-powered stone mill, known as a *gristmill*. These mills advanced flour production from a few kilograms up to several metric tons per day [52].

These early mills featured horizontal paddle wheels, eventually termed *Norse wheels* due to their prevalence in Scandinavia. The paddle wheels connected to a shaft, which, in turn, linked to the central runner stone for grinding. Water flow propelled the paddle wheels, transferring the grinding force to the stationary *bed*, typically a stone of similar size and shape. This design was straightforward, avoiding the need for gears. However, it had a limitation: the stone's rotation speed relied on water volume and flow rate, making it most suitable for regions with fast-flowing streams, often found in mountainous areas [41].

In the year 1680, a remarkable scientist by the name of Antonie van Leeuwenhoek introduced a groundbreaking innovation that would forever alter our understanding of the microscopic world and ultimately bread making. Van Leeuwenhoek, a master of lens craftsmanship, possessed an insatiable fascination with realms invisible to the naked eye. His pioneering work birthed the first modern microscope. What set Van Leeuwenhoek apart was the exceptional quality of his lenses, capable of magnifying tiny microorganisms by an astounding factor of 270. Driven by an unrelenting curiosity to unveil the unseen, he embarked on a journey of exploration. He scrutinized flies, examined lice-infested hair, and ultimately turned his gaze toward the tranquil waters of a small lake near Delft.

In this serene aquatic habitat, he made astonishing observations, discovering algae and minuscule, dancing creatures hitherto hidden from human perception. Eager to share his revelatory findings with the scientific community, Van Leeuwenhoek faced skepticism, as it was difficult to fathom that someone had witnessed thousands of diminutive, dancing entities—entities so tiny that they eluded the human eye.

Undeterred by skepticism, he continued his relentless pursuit of the unseen, directing his lens towards a brewer's beer sludge. In this obscure medium, Van Leeuwenhoek made history by becoming the first human to lay eyes upon bacteria and yeast, unraveling a previously concealed world that would revolutionize our understanding of microbiology [54].

At the same time brewers would start to experiment with utilizing the muddy leftovers of the beer fermentation to start making doughs. They would notice that the resulting bread doughs were becoming fluffy and compared to the sourdough process would lack the acidity in the final product. A popular example is shown in a report from 1875. Eben Norton Horsford wrote about the famous *Kaiser Semmeln* (Emperor's bread rolls). These are essentially bread rolls made with brewer's yeast instead of the sourdough leavening agent. As the process is more expensive, bread rolls like these were ultimately consumed by the noble people in Vienna [32].

As industrialisation began the first steam-powered grain mill was developed by Oliver Evans in 1785. Evans' design incorporated several innovations, including automated machinery for various milling processes, making it more efficient than traditional water or animal-powered mills. His steam-powered mill marked a significant advancement in industrial technology for bread making [43].

The biggest advancement of industrial breadmaking happened in 1857. The French microbiologist Louis Pasteur discovered the process of alcoholic fermentation. He would prove that yeast microorganisms are the reason for alcoholic fermentation and not other chemical catalysts. He continued with his research and was the first person to isolate and grow pure yeast strains. Soon later in 1868 in the Fleischmann brothers Charles and Maximilian were the first to patent pure yeast strains for bread making. The yeasts offered were isolated from batches of sourdough. By 1879 the machinery was built to multiply the yeast in large centrifuges [31]. The pure yeast would prove to be excellent and turbocharged at leavening bread doughs. What would previously take 10 hours to leaven a bread dough could now be done within 1 hour. The process became much more efficient. What ultimately made making large batches of dough possible, was the invention of the electrical kneader. Rufus Eastman, an American inventor, is often credited with an important advancement in mixer technology. In 1885, he received a patent for an electric mixer with a mechanical hand-crank mechanism. This device was not as advanced or as widely adopted as later electric mixers, but it was an early attempt to mechanize mixing and kneading processes in the kitchen using

Figure 1.4: A bread made over the stove without an oven.

electricity. Eastman's invention represented an important step in the development of electric mixers, but it wasn't as sophisticated or popular as later models like the KitchenAid mixer. The KitchenAid mixer, introduced in 1919, is often recognized as one of the first widely successful electric mixers and played a significant role in revolutionizing kitchen appliances for home cooks [44] [33].

During World War II the first packaged dry yeast was developed. This would ultimately allow bakeries and home bakers to make bread much faster and more consistently. Thanks to pure yeast, building industrial bread making machines was now possible. Provided you maintain the same temperature, same flour and yeast strains fermentation became precisely reproducible. This ultimately lead to the development of giga bakeries and flour blenders. The bakeries demanded the same flour from year to year to bake bread in their machines. For this reason, none of the supermarket flour you buy today is single origin. It is always blended to achieve exactly the same product throughout the years.

Modern wheat, specifically the high-yielding and disease-resistant varieties commonly grown today, began to be developed in the mid-20th century. This period is often referred to as the *Green Revolution.*

One of the key figures in this development was American scientist Norman Borlaug, who is credited with breeding high-yield wheat varieties, particularly dwarf wheat varieties, that were resistant to diseases and could thrive in various environmental conditions. His work, which started in the 1940s and continued through the 1960s, played a crucial role in increasing wheat production worldwide and alleviating food shortages [20].

As fermentation times sped up, the taste of the final bread would deteriorate. The sprouting process induced by certain enzymes is essential to developing a fluffier texture and better tasting crust. This can't be indefinitely sped up. Soon bakeries would start to introduce additional enzymes to achieve similar properties to sourdough bread in yeast-based doughs. Sourdough almost completely vanished from the surface of the Earth. Only a handful of true nerds would continue making bread with sourdough.

Suddenly people started to talk more often about celiac disease and the role of gluten. The disease isn't new; it has first been described in 250 AD [5]. People would note how modern bread has much more gluten compared to ancient bread. The bread in ancient times probably was much flatter. The grains over time have been bred more and more towards containing a higher amount of gluten. Gluten is a protein that gives modern bread its typical soft fluffy crumb structure. The gluten proteins bind together once activated with water. Throughout the course of the fermentation, CO_2 is trapped in this protein matrix. The tiny created chambers expand during the baking process. As the dough gelatinizes while being heated, the structure is fortified. This makes the bread appear soft and fluffy when tasting it. Similar to drinking raw cow's milk, your immune system might react to the consumed proteins. There is gluten intolerance and celiac disease. When people say they don't handle gluten well, it's mostly a gluten intolerance they describe. Some people describe similar issues when consuming too much lactose. If you eat a long-fermented cheese however, most of the lactose has been fermented by the tiny microorganisms. People would investigate and note how sourdough bread can typically be handled better compared to plain, fast-made factory bread. The reason for this is that enzymes take time to work the dough. Gluten is a storage protein of flour. Once sprouting is activated by adding water, the protease enzyme starts to convert the gluten into tinier amino acids that are required for sprouting. Over time you are effectively losing gluten as it's naturally broken down. Furthermore, traditionally lactic acid bacteria would start to decompose the flour-water mix. Almost everything is recycled in nature. Part of their diet is to consume the proteins in the dough. Modern bread is faster and no longer has lactic acid bacteria. Both factors together mean that you are consuming products with a much higher gluten value compared to ancient times when natural fermentation was used [30].

During the California Gold Rush, French bakers brought the sourdough culture to Northern America. A popular bread became the San Francisco sourdough. It's characterized by its unique tang (which was previously common for every bread). It however remained more of a niche food while industrial bread was on the rise. What really expedited the comeback of sourdough was the 2020 COVID-19 pandemic. Flour and yeast became scarce in the supermarkets. While flour returned yeast couldn't be found. People started to look for alternatives and rediscovered the ancient way of making sourdough bread. Soon many realized that making sourdough bread is more complex than modern yeast-based bread. You need to maintain a sourdough starter and have it in ideal shape to properly ferment your dough. Furthermore, compared to a yeast-based dough, you can't just punch the dough down and let the fermentation continue. You can overferment your dough, resulting in a sticky dough mess. This complexity led to many bakers looking for help and many thriving communities formed around the topic of homemade bread.

When interviewing Karl de Smedt (owner of the Sourdough Library) he said something that changed my way of thinking about bread: "The future of modern bread is in the past [36]."

2

How sourdough works

In this chapter, we will cover the basics of how sourdough ferments. First, we will look at the enzymatic reactions that take place in your flour the moment you add water, triggering the fermentation process. Then, in order to understand this process better, we will learn more about the yeast and bacterial microorganisms involved.

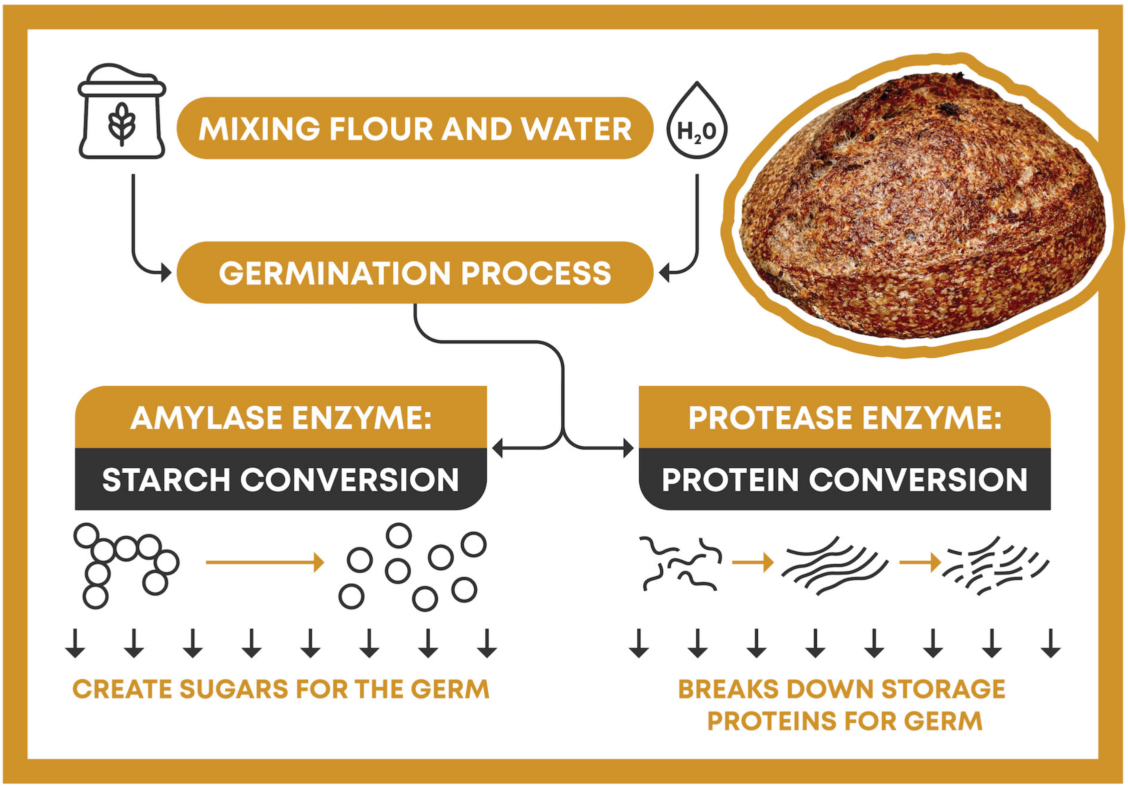


Figure 2.1: How amylases and proteases interact with flour.

2.1 Enzymatic reactions

To understand the many enzymatic reactions that take place when flour and water are mixed, we must first understand seeds and their role in the life cycle of wheat and other grains.

Seeds are the primary means by which many plants, including wheat, reproduce. Each seed contains the embryo of another plant, and must therefore contain all the nutrients that new plant requires to grow.

When the seed is dry, it is in hibernation mode and can sometimes be stored for several years. The moment it comes into contact with water, however, it begins to sprout. The seed turns into a germ, requiring the stored nutrients to be converted into something the plant can use while it grows. The catalyst that makes the associated reactions possible is water.

The seed typically contains the first prototypical leaves of the plant, and it can put down roots using the stored nutrients inside. Once those leaves break through the soil and come into contact with the sunlight above, they begin to photosynthesize. This process is the plant's engine, and with the energy photosynthesis produces, the plant can continue to grow more roots, enabling it to access additional nutrients from the soil. These additional nutrients allow the plant to grow more leaves, increasing its photosynthetic activity so that it can thrive in its new environment.

Of course, a ground flour can no longer sprout. But the enzymes that trigger this process are still present. That's why it's important not to mill grains at too high a temperature, as doing so could damage some of these enzymes.[1]

Normally, the grain seed shields the germ against pathogens. However, as the grain is ground into flour, the contents of the seed are exposed. This is ideal for our sourdough microorganisms.

Neither the yeast nor the bacteria can prepare their own food. However, as the enzymes are activated, the food they need becomes available, allowing them to feed and multiply.

The two main enzymes involved in this process are *amylase* and *protease*. For reasons that will soon be made clear, they are of the utmost importance to the home baker, and their role in the making of sourdough is a key puzzle piece to making better-tasting bread.

[1] In a recent study [47] tests have shown that milling flour at home with a small mill had no significant negative impact on the resulting bread quality compared to milled flour from temperature-regulated large-scale mills.

2.1.1 Amylase

Sometimes, when you chew on a potato or a piece of bread for a long period of time, you'll perceive a sweet flavor on your tongue. That's because your salivary glands produce amylase. Amylase breaks down complex starch molecules into easily-digestible sugars. Your body uses amylase to start the digestive process. The germ works similarly by using the same enzyme. The amylase is used to create sugars out of the starch to then produce more plant matter.

Normally, the microorganisms on the surface of the grain can't consume the freed maltose molecules, which remain hidden inside the germ. But as we grind the flour, a feeding frenzy takes place. Generally, the warmer the temperature, the faster this reaction occurs. That's why a long fermentation is key to making great bread. It takes time for the amylase to break down most of the starch into simple sugars, which are not only consumed by the yeast but are also essential to the *Maillard reaction*, responsible for enhanced browning during the baking process.

If you're a hobby brewer, you'll know that it's important to keep your beer at certain temperatures to allow the different amylases to convert the contained starches into sugar [24]. This process is so important that there's a frequently used test to determine whether or not all the starches have been converted. This test, called the *Iodine Starch Test*, involves mixing iodine into a sample of your brew and checking the color. If it's blue or black, you know you still have unconverted starches. I wonder if such a test would also work for bread dough?

Industrial bakers who add especially active yeast to produce bread in a short period of time face a similar issue. Their approach is to add malted flour to the dough, this malted flour contains many enzymes and thus speeds up the fermentation process. The next time you're at the supermarket, check the packaging of the bread you buy. If you find *malt* in the list of ingredients, chances are this strategy was used.

Note that there are actually two categories of malt. One is *enzymatically active malt*, which has not been heated to above 70 °C, where the amylases begin to degrade. The other is *inactive malt*, which has been heated to higher temperatures and thus has no impact on your flour.

2.1.2 Protease

Just as amylase breaks starches down into simple sugars, protease breaks complex proteins down into simpler proteins and amino acids. Because wheat contains gluten, a protein that's essential to the structure of bread, protease necessarily plays a crucial role in the baking of sourdough.

Since the grain seeds require smaller amino acids to build roots and other plant materials, the gluten in those seeds will begin to break down the moment they sprout, and since adding water to flour activates those same enzymes, the same process occurs in bread dough.

If you've ever tried to make a wheat-based dough and kept it at room temperature for several days, you'll have discovered for yourself that the gluten network breaks down to the point that the dough can no longer hold together. Once this happens, the dough easily tears, holds no structure, and is no longer suitable for baking bread.

This happened to me once when I tried to make sourdough directly from a dried starter. At three to four days, the fermentation speed was so slow that the gluten network broke down. The root cause for this issue was protease. By adding water to your dough, you activate the protease, and this gets to work in readying amino acids for the germ.

Here's another interesting experiment you can try to better visualize the importance of protease: Make a fast-proofing dough using a large quantity of active dry yeast. In 1–2 hours, your dough should have leavened and increased in size. Bake it, then examine the crumb structure. You should see that it's quite dense and nowhere near as fluffy as it could have been. That's because the protease enzyme wasn't given enough time to do its job.

At the start, while kneading, a dough becomes elastic and holds together very well. As that dough ferments, however, it becomes more loose and extensible [21]. This is because some of the gluten bonds have been broken down naturally by the protease through a process known as *proteolysis*. This is what makes it easier for the yeast to inflate the dough, and it's why a long fermentation process is critical when you want to achieve a fluffy, open crumb with your sourdough bread.

Aside from using great ingredients, the slow fermentation process is one of the main reasons Neapolitan pizza tastes so great: because the protease creates an extensible and easy-to-inflate dough a soft and airy edge is achieved.

Because the fermentation process typically takes longer than 8 hours, a flour with a higher gluten content should be used. This gives the dough more time to be broken down by the protease without negatively affecting its elasticity. If you were to use a weaker flour, you might end up with a dough that's broken down so much that it tears during stretching, making it impossible, for example, to shape it into a pizza pie.

Traditionally, pizza has been made with sourdough, but in modern times it is made with active dry yeast. As the dough stays good for a longer period of time it is much easier to handle on a commercial scale. If you were to use sourdough, you might have a window of thirty to ninety minutes before the dough begins to deteriorate, due to both the protease acting for a longer period of time and the byproducts of bacteria, which we'll discuss in more detail later in this chapter.

2.1.3 Improving enzymatic activity

As explained previously, malt is a common trick used to speed up enzymatic activity. Personally, however, I prefer to avoid malt and instead use a trick I learned while making whole-wheat breads.

When I first started making whole-wheat bread, I could never achieve the crust, crumb, or texture I desired no matter what I tried. Instead, my dough tended to overferment rather quickly. When using a white flour with a similar gluten content, however, my bread always turned out great.

At the time, I utilized an extended autolyse, which is just a fancy word for mixing flour and water in advance and then letting the mixture sit. Most recipes call for it as the process gives the dough an enzymatic head start, and in general it's a great idea. However, as an equally effective alternative, you could simply reduce the amount of leavening agent used — in the case of sourdough, this would be your starter. This would allow the same biochemical reactions to occur at roughly the same rate without requiring you to mix your dough several times. My whole-wheat game improved dramatically after I stopped autolysing my doughs.

Now that I've had time to think about it, the result I observed makes sense. In nature, the outer parts of the seed come into contact with water first, and only after penetrating this barrier would the water slowly find its way to the center of the grain. The seed needs to sprout first to outcompete other nearby seeds, requiring water to enter quickly. Yet the seed must also defend itself against animals and potentially hazardous bacteria and fungi, requiring some barrier to protect the embryo inside. A way for the plant to achieve both goals would be for most of the enzymes to exist in the outer parts of the hull. As a result, they are activated first [45]. Therefore, by just adding a little bit of whole flour to your dough, you should be able to significantly improve the enzymatic activity of your dough. That's why, for plain white flour doughs, I usually add 10–20% whole-wheat flour.

By understanding the two key enzymes *amylase* and *protease*, you will be better equipped to make bread to your liking. Do you prefer a softer or stiffer crumb? Do you desire a lighter or darker crust? Do you wish to reduce the amount of gluten in your final bread? These are all factors that you can tweak just by adjusting the speed of your dough's fermentation.

2.2 Yeast

Yeasts are single-celled microorganisms belonging to the fungi kingdom. They can reproduce through either budding or by building spores. The spores are incredibly tiny and resistant to external factors. Scientists have found undamaged spores that are hundreds of million years old. There are a wide variety of species — so far, about 1500

Figure 2.2: A whole-wheat sourdough bread.

have been identified. Unlike other members of the fungi kingdom such as mold, yeasts do not ordinarily create a mycelium network [8].[2]

Yeasts are saprotrophic fungi. This means that they do not produce their own food, but instead rely on external sources that they can decompose and break down into compounds that are more easily metabolized. What we today refer to as the fermentation process, is the yeast breaking down carbohydrates into carbon dioxide and alcohol. This process has been known for thousands of years, and has been used since ancient times for the making of bread as well as alcoholic beverages.

Yeast can grow and multiply under both aerobic and anaerobic conditions. When oxygen is present, they produce carbon dioxide and water almost exclusively. When oxygen is not present, their metabolism changes to produce alcoholic compounds [7].

The temperatures at which yeast grows varies. Some yeasts, such as *Leucosporidium frigidum*, do best at temperatures ranging from −2 °C to 20 °C, while others prefer higher temperatures. In general, the warmer the environment, the faster the yeast's metabolism. The variety of yeast that you cultivate in your sourdough starter should work best within the range of temperatures where the grain was grown and harvested. So, if you are from a cooler place and cultivate a sourdough starter from a nordic rye variety, chances are your yeast will prefer a colder environment.

As an example, beer makers discovered a beneficial yeast living in the cold caves around the city of Pilsen, Czech Republic. This yeast has since become known for producing

[2]For one interesting exception, skip ahead to the end of this section on page 16.

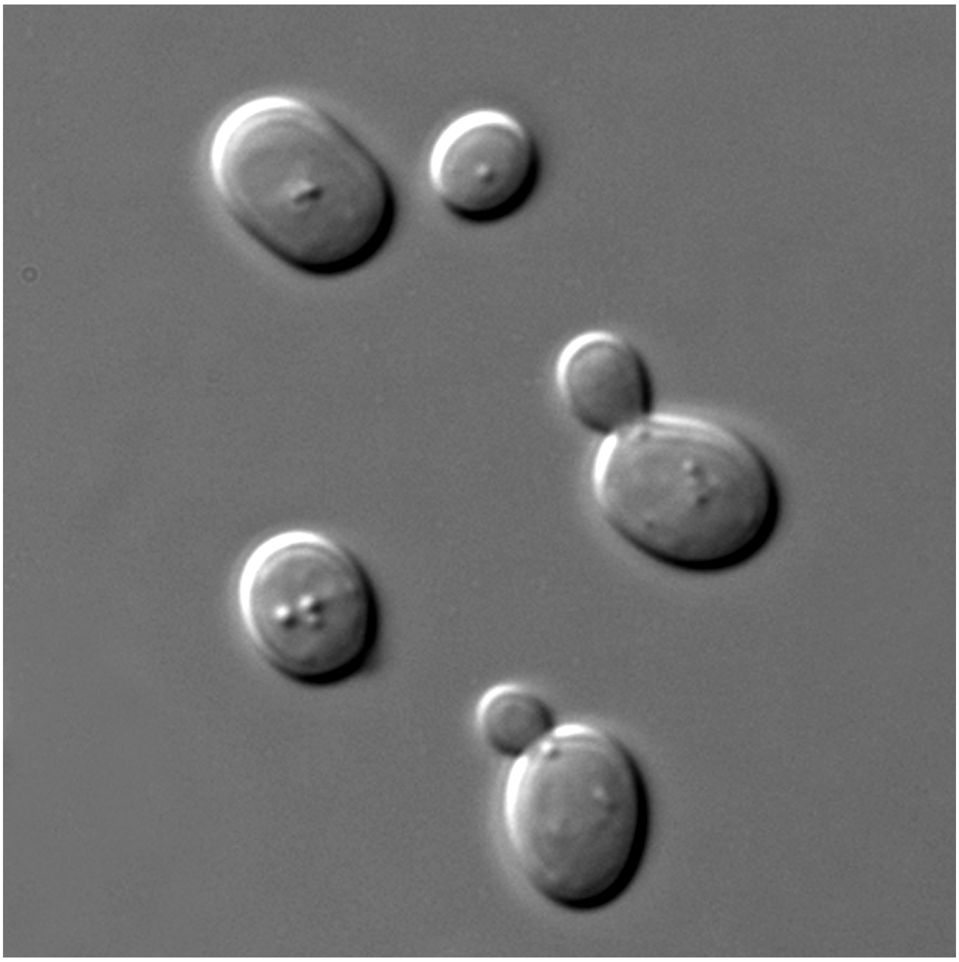


Figure 2.3: Saccharomyces cerevisiae: Brewer's yeast under the microscope.

excellent beers at lower temperatures and varieties of these strains are now used for brewing popular lagers.

Yeasts in general are very common organisms. They can be found on cereal grains, fruits, and many other plants in the soil. They can even be found inside your gut! As it happens, the types of yeast we use for baking are cultivated on the leaves of plants, though very little is known about the ecology involved.

Plants are protected by thick cell walls that few fungi or bacteria can penetrate. However, there are some species that produce enzymes capable of breaking down those cell walls so they can infect the plant.

Some fungi and bacteria live inside plants without causing them any distress. These are known as *endophytes*. Not only do they *not* damage their host, they actually live in a symbiotic relationship. They help the plants in which they dwell to protect themselves from other pathogens that might also come to infect them through their leaves. In addition to this protection, they also help with water and heat stress, as well as the availability of nutrients. In exchange for their service to their host plants, these fungi and bacteria receive carbon for energy.

However, the relationship between endophyte and plant is not always mutually beneficial, and sometimes, under stress, they become invasive pathogens and ultimately cause their host to decay [11].

There are other microorganisms that, unlike endophytes, do not penetrate cell walls but instead live on the plant's surface and receive nutrients from rain water, the air, or other animals. Some even feed on the honeydew produced by aphids or the pollen that lands on the surface of the leaves. Such organisms are called *epiphytes*, and included among them are the types of yeast we use for baking.

Interestingly, when you remove external food sources, a large number of epiphytic fungi and bacteria can still be found on the plant's surface, suggesting that they must somehow be feeding directly from the plant. Indeed, there is some research indicating that some plants intentionally release compounds such as sugars, organic and amino acids, methanol, and various salts along the surface. These nutrients would then attract the epiphytes that live on the plant's surface.

Epiphytes are advantageous to a plant's survival, as they are provided with enhanced protection against mold and other pathogens. Indeed, it is in the best interest of the epiphytes to keep their host plants alive for as long as possible [42].

More research is conducted every day into ways that yeasts can be used as biocontrol agents to protect plants, the advantage being that these bio-agents would be food-safe as the relevant strains of yeast are generally considered harmless to humans. The yeasts would grow and multiply on the leaves, essentially shielding them from other types of mold. This could be a potential game changer for vineyards that suffer from mildew.

Such bio-agents could also be used to shield plants against the psychoactive ergot fungus, which likes to grow in colder, more humid environments and poses a significant problem for rye farmers. Lawmakers have recently reduced the amount of allowed ergot contamination in rye flour because it infects the grain and makes it unfit for consumption due to its high toxicity to the liver. Yeasts could help to mitigate ergot contamination.

There is another interesting experiment performed by Italian scientists that shows how crucial yeasts could be in protecting our crops. First, they made tiny incisions into some of the grapes on a vine. Then, they infected the wounds with mold. Some incisions were only infected with mold. Others were also inoculated with some of the 150 different wild yeast strains isolated from the leaves. They found that when the wound was inoculated with yeast, the grape sustained no significant damage [4].

Intriguingly, there was also an experiment performed that showed how brewer's yeast could function as an aggressive pathogen to grapevines. Initially, the yeast lived in symbiosis with the plants, but after the vines sustained heavy damage, the yeast became opportunistic and started to attack, even going so far as to produce hyphae,

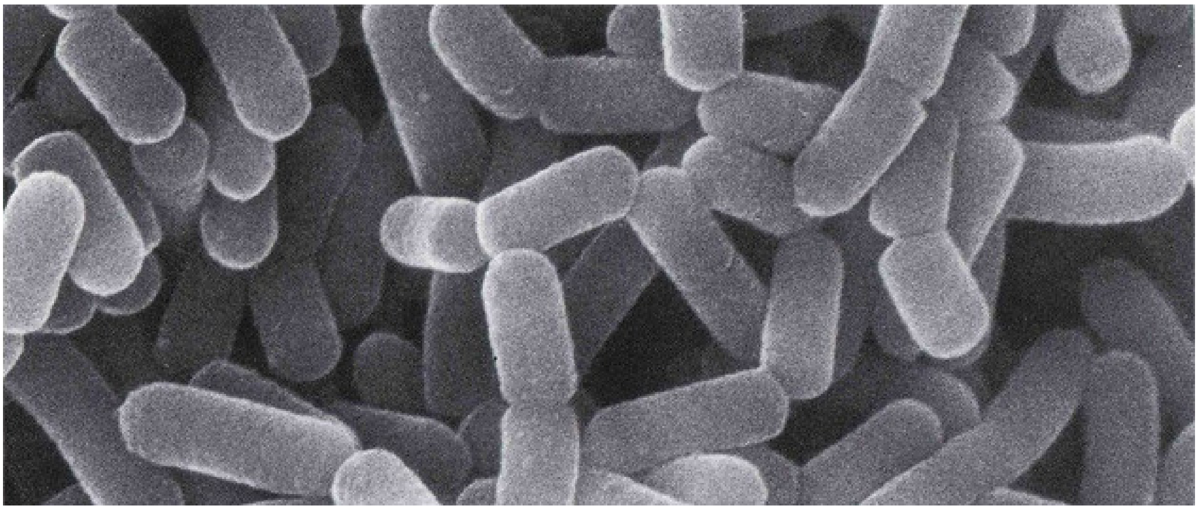


Figure 2.4: Fructilactobacillus sanfranciscensis under the microscope.

the mycelium network normally associated with a fungus, so that they could penetrate the tissue of the plants.

2.3 Bacteria

The other most dominant microbial antagonists in your sourdough are bacteria. In fact, they are so dominant that they outnumber the yeast in your dough 100 to 1. Whereas yeast provides leavening power, bacteria create the distinct flavours for which sourdough has been named. These are due to the acidic byproducts that result from bacterial feeding. As a bonus, these acids can significantly increase the shelf life of sourdough breads [13].

There are two predominant types of acid produced in sourdough bread: lactic and acetic. In terms of flavor, lactic acid has clear dairy notes, while acetic acid tastes of vinegar (of which it is, in fact, the primary ingredient!). These acidic byproducts are produced by both *homofermentative* and *heterofermentative* lactic acid bacteria.

Homofermentative means that, during fermentation, the bacteria produce a single compound: in this case, lactic acid. *Heterofermentative*, on the other hand, means that other compounds are also produced: in this case, not only lactic acid, but also acetic acid, as well as ethanol and even some carbon dioxide, two byproducts ordinarily associated with yeast. One quite famous strain of lactic acid bacteria, *Fructilactobacillus sanfranciscensis*, derives its name from the equally famous San Francisco style sourdough bread. The first isolated culture came from a bakery in this city, hence the name.

Yeast and bacteria both compete for the same food source: sugar. Some scientists have reported that bacteria consume mostly maltose, while yeast prefer glucose. Others have reported that bacteria feed on the byproducts of yeast and vice versa. This makes sense, as nature generally does a superb job of composting and breaking down biological matter [9].

I have yet to find a proper source that clearly describes the symbiosis between yeast and bacteria, but my current understanding is that they both coexist and sometimes benefit each other, but not always. Yeast, for example, tolerate the acidic environment created by the surrounding bacteria and are thus protected from other pathogens. Meanwhile, however, other research demonstrates that both types of microorganisms produce compounds that prevent the other from metabolizing food — an interesting observation, by the way, as it could help to identify additional antibiotics or fungicides [27].

In the past, I've tried cultivating mushrooms and observed the mycelium attempting to defend itself against the surrounding bacteria; both types of microorganisms actively produced compounds to combat each other. And yet, after a while, the fight seemed to reach a standstill, as the mycelium had fully grown around the bacterial patch, preventing it from spreading further. I imagine a similar scenario could be playing out in our sourdough starters, although, given that the sourdough environment tends to be more liquid, this fight would have to take place everywhere in the dough and not just in an isolated patch. More research on this topic is required to get a better understanding of the details of the relationship between yeast and bacteria.

One other interesting trait of sourdough bacteria worth mentioning is their ability to break down and consume the proteins in your dough. If you've baked sourdough before, chances are you've experienced this firsthand. You'll recall from the *Enzymatic reactions* section that protease breaks down the gluten network in your dough, resulting in a sticky mess if left unbaked for too long. The bacteria, too, consume and break down the gluten in your dough through a process called *proteolysis*.

This, to me, was a great riddle when I first started working with sourdough. On the one hand, it makes the dough stickier. On the other, it makes the dough more extensible and easier to work with. As the gluten is reduced, the dough becomes easier for the microorganisms to inflate, allowing it to rise. This could be likened to the level of effort required to inflate a thick rubber tire versus a thin and fragile balloon. The latter would be easy to blow up with your mouth, while the former would not.

Unsurprisingly, proteolysis is further accelerated by the protease enzyme previously discussed, which aids in the breakdown of gluten into smaller, more easily metabolized amino acids.

This, to me, is the amazing process of fermentation. When you eat sourdough bread, you are not merely consuming flour and water but the end result of complex biological processes accomplished by the bacteria and yeast. Because of the added bacterial component, sourdough bread typically contains less gluten than a pure yeast-based dough [6]. Furthermore, the homofermentative bacteria metabolize the ethanol produced by the yeast and other heterofermentative lactic acid bacteria. In both cases, most of the resulting compounds are organic acids. Every natural resource in your sourdough bread is recycled by the microorganisms inside, which are all trying to eat whatever is available for as long as possible, and with each feeding, they become more adept at utilizing these resources.

Depending on which flavour profile you prefer, you can select for one organic acid or another. Acetic acid production requires oxygen, and by depriving your sourdough starter of it, you can boost the population of homofermentative lactic acid bacteria. Over time they will become dominant and outcompete the acetic acid-producing bacteria [3].

The optimal fermentation temperature of your lactic acid bacteria depends on the strains you've cultured in your starter. Generally, they work best at the temperature used to create your starter because you've already selected for bacteria that thrive under that condition.

In one noteworthy experiment, scientists examined the lactic acid bacteria found on corn leaves. They lowered the ambient temperature from 20 °C to 25 °C to around 5 °C to 10 °C and afterward observed varieties of the bacteria that had never been seen before [14], confirming that there is, in fact, a large variety of bacterial strains living on the leaves of the plant.

Incidentally, you could perform a similar experiment by kicking off a sourdough starter at a lower temperature. In theory, the microbiome should adapt, as the microorganisms that thrive the most at lower temperatures will start to become dominant. It would be interesting to see if this could actively influence the taste of the resulting bread.

One last footnote worth mentioning: Some sources say that fermenting at a lower temperature can increase acetic acid production, while fermenting at a warmer temperature can boost lactic acid production. I could not verify this in my own tests. More research is needed on the topic.

3

Making a sourdough starter

In this chapter you will learn how to make your own sourdough starter, but before doing so you will quickly learn about baker's math. Don't worry, it's a very simple way how to write a recipe which is cleaner and more scalable. Once you get the hang of it you will want to write every recipe this way. You will learn to understand the signs indicating your starter's readiness, as well as how to prepare your starter for long-term storage.

3.1 Baker's math

In a large bakery, a determining factor is how much flour you have at hand. Based on the amount of flour you have, you can calculate how many loaves or buns you can make. To make it easy for bakers, the quantity of each ingredient is calculated as a percentage based on how much flour you have. Let me demonstrate this with a small example from a pizzeria. In the morning you check and you realize you have around 1 kg of flour. Your default recipe calls for around 600 g of water. That would be a typical pizza dough, not too dry but also not too wet. Then you would be using around 20 g of salt and around 100 g of sourdough starter.[1] The next day you suddenly have 1.4 kg of flour at hand and thus can make more pizza dough. What do you do? Do you multiply all the ingredients by 1.4? Yes you could, but there is an easier way. This is where baker's math comes in handy. Let's look at the default recipe with baker's math and then adjust it for the 1.4 kg flour quantity.

Note how each of the ingredients is calculated as a percentage based on the flour. The 100 % is the baseline and represents the absolute amount of flour that you have at hand. In this case that's 1000 g (1 kg).

Now let's go back to our example and adjust the flour, as we have more flour available the next day. As mentioned the next day we have 1.4 kg at hand (1400 g).

[1]This is my go to pizza dough recipe. In Napoli modern pizzerias would use fresh or dry yeast. However traditionally pizza has always been made with sourdough.

Ingredient		Percentage	Calculation		
Flour	1000 g	100 %	1000 g of 1000 g	is	100 %
Water	600 g	60 %	600 g of 1000 g	is	60 %
Sourdough starter	100 g	10 %	100 g of 1000 g	is	10 %
Salt	20 g	2 %	20 g of 1000 g	is	2 %

Table 3.1: An example table demonstrating how to properly calculate using baker's math

Ingredient	Baker's math	Calculated value		
Flour	100 %	1400×1	=	1400 g
Water	60 %	1400×0.6	=	840 g
Sourdough starter	10 %	1400×0.1	=	140 g
Salt	2 %	1400×0.02	=	28 g

Table 3.2: An example recipe that uses 1400 g as its baseline and is then calculated using baker's math.

For each ingredient we calculate the percentage based on the flour available (1400 g). So for the water we calculate 60 % based on 1400. Open up your calculator and type in 1400×0.6 and you have the exact value in grams that you should be using. For the second day, that is 840 g. Proceed to do the same thing for all the other ingredients and you will know your recipe.

Let's say you would want to use 50 kg of flour the next day. What would you do? You would simply proceed to calculate the percentages one more time. I like this way of writing recipes a lot. Imagine you wanted to make some pasta. You would like to know how much sauce you should be making. Now rather than making a recipe just for you, a hungry family arrives. You are tasked with making pasta for 20 people. How would you calculate the amount of sauce you need? You go to the internet and check a recipe and then are completely lost when trying to scale it up.

3.2 The process of making a starter

Making a sourdough starter is very easy, all you need is a little bit of patience. It is in fact so easy that it can be summarized in a simple flowchart 3.1 The flour you should use to bootstrap your starter is ideally a whole flour. You could use whole-wheat, whole-rye, whole-spelt or any other flour you have. In fact gluten free flours such as rice or corn would also work. Don't worry, you can always change the flour later. Use whatever whole flour you already have at hand.

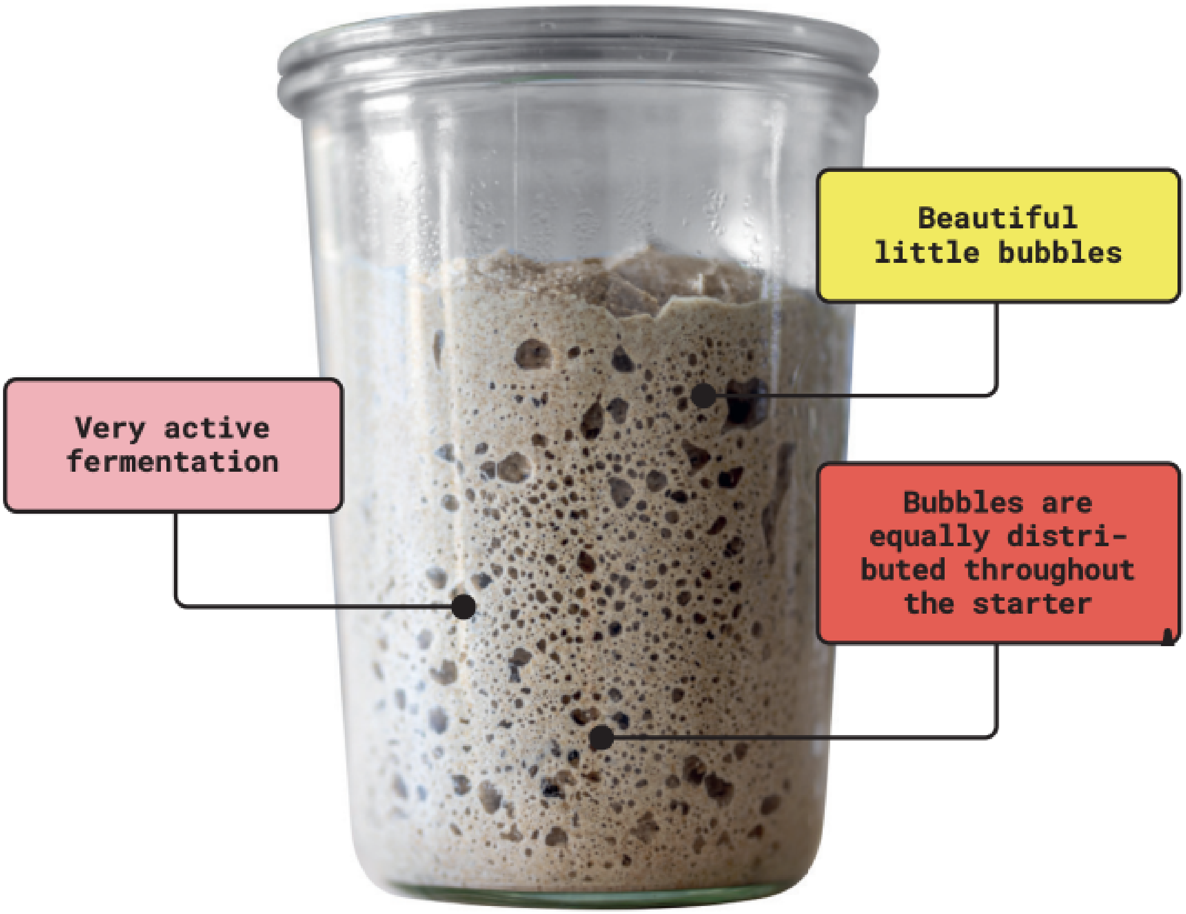


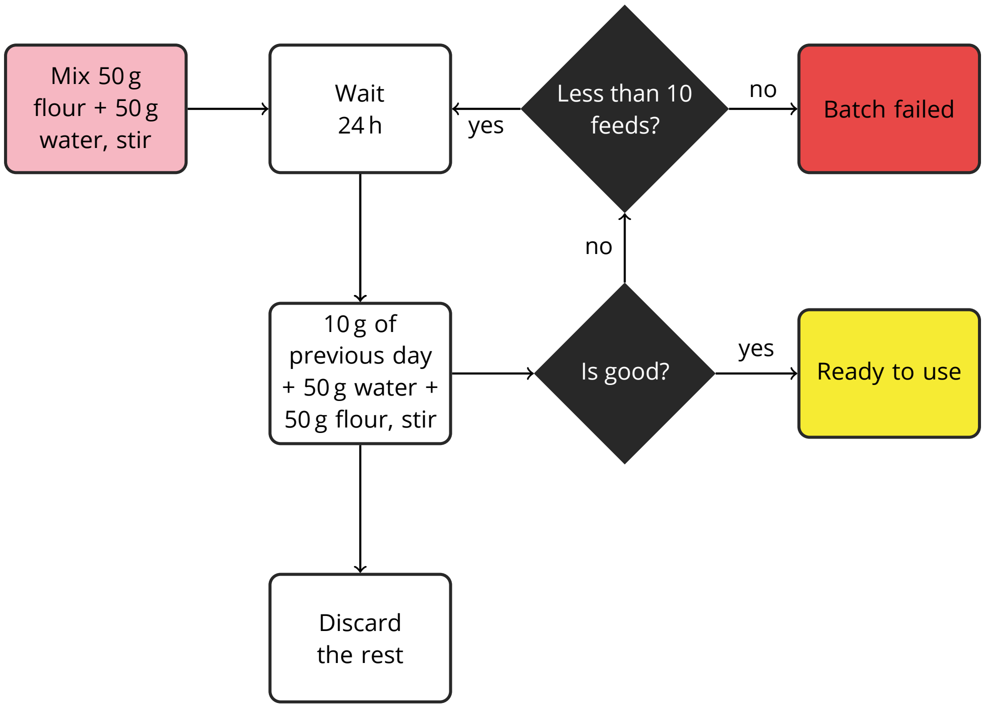
Figure 3.1: A very active sourdough starter shown by the bubbles in the dough.

Your flour is contaminated with millions of microbes. As explained before in the chapter about wild yeast and bacteria, these microbes live on the surface of the plant. That's why a whole flour works better because you have more natural contamination from the microbes you are trying to cultivate in your starter. More of them live on the hull compared to the endophytes living in the grain.

Start by measuring approximately 50 g of both flour and water. The measurements don't have to be exact; you can use less or more, or just eyeball the proportions. These values are just shown as a reference.

Don't use chlorinated water when setting up your starter. Ideally, you should use bottled water. In certain regions like Germany, tap water is perfectly fine. Chlorine is added to water as a disinfectant to kill microorganisms, you will not be able to grow a starter with chlorinated water.

In this process, the hydration of your starter is 100 %. This means you're using equal amount of flour and water. Stir everything together so that all the flour is properly hydrated. This step activates the microbial spores in your mixture, drawing them out of hibernation and reviving them. Finally, cover your mixture but make sure the covering is not airtight. You still want some gas exchange to be possible. I like to use a glass and place another inverted one on top.



Flowchart 3.1: The process of making a sourdough starter from scratch.

Now an epic battle begins. In one study [4] scientists have identified more than 150 different yeast species living on a single leaf of a plant. All of the different yeasts and bacteria are trying to get the upper hand in this battle. Other pathogens such as mold are also being activated as we added water. Only the strongest most adaptable microorganisms will survive.

By adding water to the flour the starches start to degrade. The seedling tries to sprout but it no longer can. Essential for this process is the amylase enzyme. The compact starch is broken down to more digestible sugars to fuel plant growth. Glucose is what the plant needs in order to grow. The microorganisms that survive this frenzy are adapted to consuming glucose.

Luckily for us bakers, the yeast and bacteria know very well how to metabolize glucose. This is what they have been fed in the wild by the plants. By forming patches on the leaf and protecting the plant from pathogens they received glucose in return for their services. Each of the microbes tries to defeat the other by consuming the food fastest, producing agents to inhibit food uptake by others or by producing bactericides and/or fungicides. This early stage of the starter is very interesting as more research could possibly reveal new fungicides or antibiotics.

Depending on where your flour is from, the starting microbes of your starter might be different than the ones from another starter. Some people have also reported how the microbes from your hand or air can influence your starter's microorganisms. This makes sense to a certain extent. Your hand's microbes might be good at fermenting your sweat, but probably not so good at metabolizing glucose. The contamination of your hands or air might play a minor role in the initial epic battle. But only the fittest microbes fitting the sourdough's niche are going to survive.

This means the microorganisms knowing how to convert maltose or glucose will have the upper hand. Or the microbes fermenting the waste of the other microbes. Ethanol created by the yeast is metabolized by the bacteria in your sourdough. That's why a sourdough has no alcohol. I can confirm the role of aerial contamination to a certain extent, when setting up a new sourdough starter the whole process is quite quick for me. After a few days my new starter seems to be quite alive already. This might be due to previous contamination of flour fermenting microbes in my kitchen.

Figure 3.2: A simple visualization of the microbial warfare that happens during the making of a sourdough starter. The wild spores on the plant and flour become activated the moment flour and water is mixed. Only the most adapted flour-fermenting microbes will survive. Because of unwanted microbial fermentation it is advised to discard the feeding-leftovers of the first days. The surviving yeast and bacteria continuously try to outcompete each other for resources. New microbes have a hard time entering the starter and are eliminated.

Wait for around 24 hours and observe what happens to your starter. You might see some early signs of fermentation already. Use your nose to smell the dough. Look for bubbles in the dough. Your dough might already have increased in size a little bit. Whatever you see and notice is a sign of the first battle.

Some microbes have already been outperformed. Others have won the first battle. After around 24 hours most of the starch has been broken down and your microbes are hungry for additional sugars. With a spoon take around 10 g from the previous day's mixture and place it in a new container. Again — you could also simply eye ball all the quantities. It does not matter that much. Mix the 10 g from the previous day with another 50 g of flour and 50 g of water.

Note the ratio of 1:5. I very often use 1 part of old culture with 5 parts of flour and 5 parts of water. This is also very often the same ratio I use when making a dough. A dough is nothing else than a giant sourdough starter with slightly different properties. I'd always be using around 100 g to 200 g of starter for around 1000 g of flour (baker's math: 10 % to 20 %).

Homogenize your new mixture again with a spoon. Then cover the mix again with a glass or a lid. If you notice the top of your mixture dries out a lot consider using another cover. The dried-out parts will be composted by more adapted microbes such as mold. In many user reports, I saw mold being able to damage the starter when the starter itself dried out a lot.

You will still have some mixture left from your first day. As this contains possibly dangerous pathogens that have been activated make sure you discard this mixture. A rule of thumb is to begin keeping the discard, the moment you made your first successful bread. At that point your discard is long-fermented flour that is an excellent addon used to make crackers, pancakes or delicious hearty sandwich bread...I also frequently dry it and use it as a rolling agent for pizzas that I am making.[2]

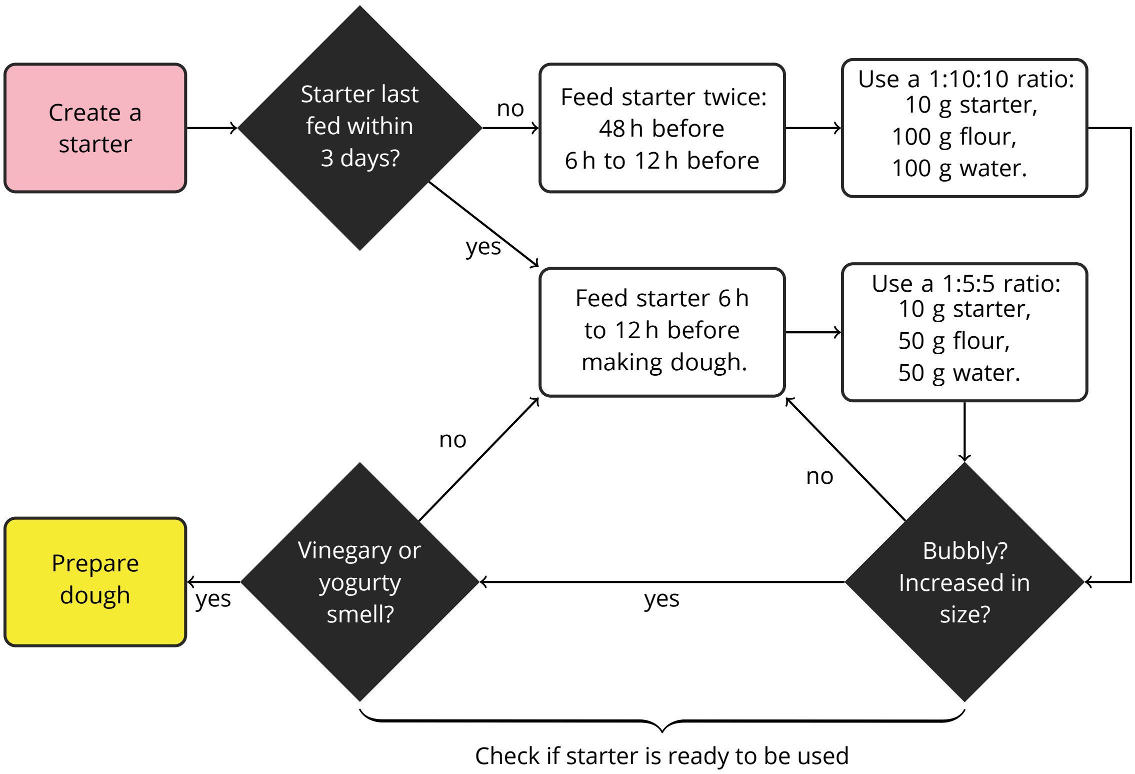
You should hopefully again see some bubbles, the starter increasing in size and/or the starter changing its smell. Some people give up after the second or third day, because the signs might no longer be as dominant as they were on day one. The reason for this lies in only a few select microbes starting to take over the whole sourdough starter. The most adaptable ones are going to win, they are very small in quantity and will grow in population with each subsequent feeding. Even if you see no signs of activity directly, do not worry, there is activity in your starter at a microscopic level.

[2] Discarding starter when preparing a new batch can be frustrating. With experience, bread-making becomes more efficient, and excess discard is rarely produced. It is possible to prepare just the right amount of starter needed for bread dough. In fact, a fully depleted starter can even be revived using a small portion of bread dough. Any leftover discard, rich in spores, can also serve as a backup to create a new sourdough starter. Simply mix the discard with a little flour and water, and it will spring back to life. That is a great option if the starter was accidentally depleted. A practical approach is to store all discard in a single jar in the fridge, adding new discard on top as needed and using it whenever required.

24 hours later again we will repeat the same thing again until we see that our sourdough starter is active. More on that in the next section of this book.

3.3 Determining starter readiness

For some people the whole process of setting up a starter takes only 4 days. For others it can take 7 days, for some even 20 days. This depends on several factors including how good your wild microbes are at fermenting flour. Generally speaking, with each feeding your starter becomes more adapted to its environment. Your starter will become better at fermenting flour. That's why a very old and mature starter you receive from a friend might be stronger than your own starter initially. Over time your sourdough starter will catch up. Similarly, modern baking yeast has been isolated like this from century old sourdough starters.



Flowchart 3.2: A flow chart showing you how to determine if your sourdough starter is ready to be used. Make sure to wait at least 6 h to 12 h after feeding your starter to check its readiness. To evaluate it, look at your starter's size increase, airy texture and take note of its smell. All three factors are important to properly evaluate your starter's activity level. An active starter is an important foundation for a successful dough fermentation

The key sign to look at is bubbles that you see in your starter jar. This is a sign that the yeast is metabolizing your dough and creates CO_2. The CO_2 is trapped in your dough matrix and then visualized on the edges of the container.

Also note the size increase of your dough. The amount the dough increases in size is irrelevant. Some bakers claim it doubles, triples or quadruples. The amount of size increase depends on your microbes, but also on the flour that you use to make the starter. Wheat flour contains more gluten and will thus result in a larger size increase. At the same time the microbes are probably not more active compared to when living in rye sourdough. You could only argue that wheat microbes might be better at breaking down gluten compared to rye microbes. That's one of the reasons why I decided to change the flour of my sourdough starter quite often. I had hoped to create an all-around starter that can ferment all sorts of different flour.[3]

Your nose is also a great tool to determine starter readiness. Depending on your starter's microbiome you should notice either the smell of lactic acid or acetic acid. Lactic acid has dairy yogurty notes. The acetic acid has very strong pungent vinegary notes. Some describe the smell as glue or acetone. Combining the visual clues of size increase and pockets plus the smell is the best way to determine starter readiness.

In rare events your flour might be treated and prevent microbe growth. This can happen if the flour is not organic and a lot of biochemical agents have been used by the farmer. In that case simply try again with different flour. Ten days is a good period of time to wait before trying again.

Another methodology used by some bakers is the so called *float test*. The idea is to take a piece of your sourdough starter and place it on top of some water, if the dough is full with gas it will float on top of the water. If it's not ready, it can't float and will sink to the bottom. This test does not work with every flour, rye flour for instance can't retain the gas as well as wheat flour and thus in some cases will not float. That's why I personally don't use this test and can't recommend it.

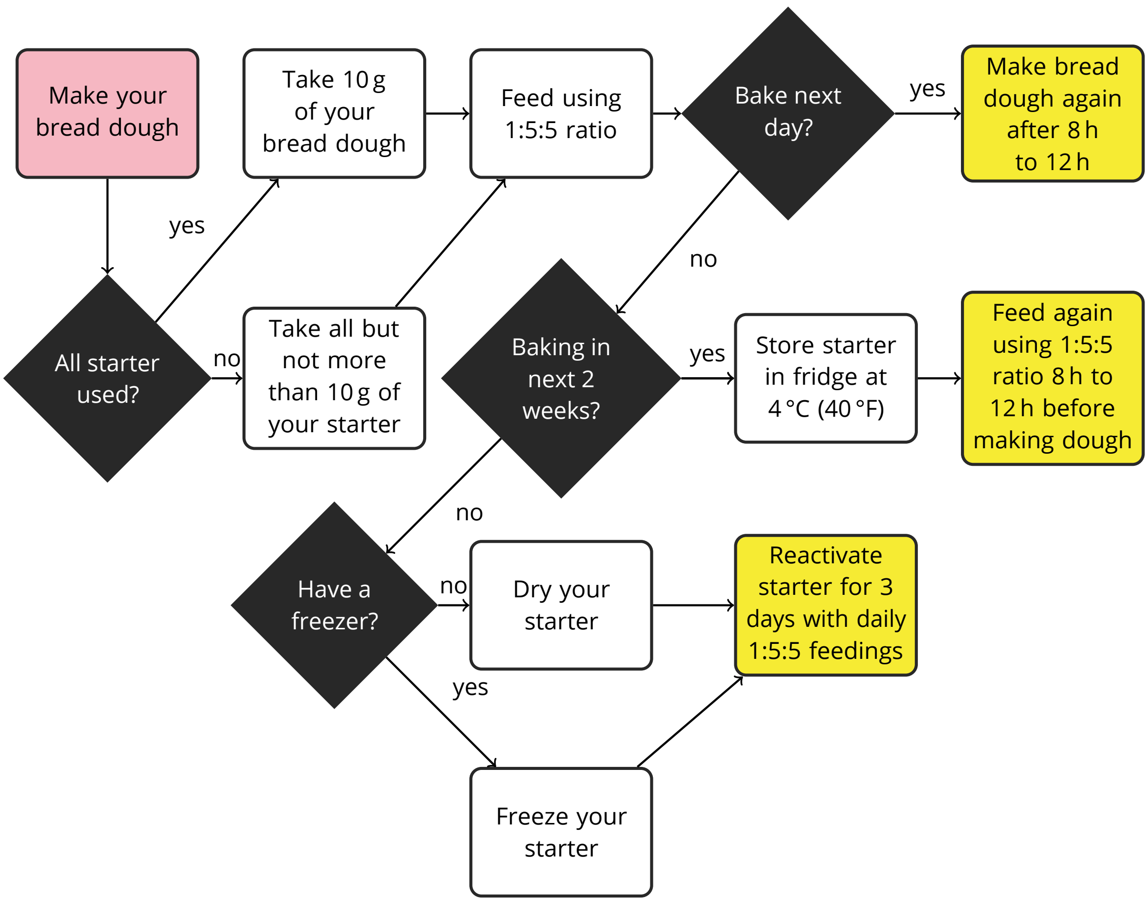
Once you see your starter is ready I would recommend giving it one last feeding and then you are ready to make your dough in the evening or the next day. For the instructions on how to make your first dough please refer to the next chapters (7 and 8) in this book.

If your first bread failed, chances are your fermentation hasn't worked as expected. In many cases the reason is your sourdough starter. Maybe the balance of bacteria and yeast isn't optimal yet. In that case a good solution is to keep feeding your starter once per day. With each feeding your starter becomes better at fermenting flour. The microbes will adapt more and more to the environment. Please also consider reading

[3]Whether this is working, I can't scientifically say. Typically the microbes that have once taken place are very strong and won't allow other microbes to enter. My starter has initially been made with rye flour. So chances are that the majority of my microorganisms are from a rye source.

the stiff sourdough starter chapter in this book. The stiff sourdough starter helps to boost the yeast part of your sourdough and balance the fermentation.

3.4 Maintenance



Flowchart 3.3: A full flowchart showing you how to conduct proper sourdough starter maintenance. You can use a piece of your dough as the next starter. You can also use left-over starter and feed it again. Choose an option that works best for your own schedule. The chart assumes that you are using a starter at a 100 % hydration level. Adjust the water content accordingly when you use a stiff starter.

You have made your sourdough starter and your first bread. How do you perform maintenance for your starter? There are countless different maintenance methods out there. Some people go completely crazy about their starter and perform daily feedings of the starter. The key to understanding how to properly conduct maintenance is to understand what happens to your starter after you used it to make a dough. Whatever starter you have left, or a tiny piece of your bread dough can serve to make your next starter.[4]

As explained earlier your starter is adapted to fermenting flour. The microbes in your starter are very resilient. They block external pathogens and other microbes. That is the reason why, when buying a sourdough starter, you will preserve the original microbes. It is likely that they are not going to change in your starter. They are outcompeting other microbes when it comes to fermenting flour. Normally everything in nature starts to decompose after a while. However, the microbes of your starter have very strong defense mechanisms. In the end, your sourdough starter can be compared to pickled food. Pickled food has been shown to stay good for a very long period of time [1]. The acidity of your sourdough starter is quite toxic to other microbes. The yeast and bacteria though have adapted to living in the high-acid environment. Compare this to your stomach, the acidity neutralizes many possible pathogens. As long as your starter has sufficient food available it will outcompete other microbes. When the starter runs out of food the microbes will start to sporulate. They prepare for a period of no food and will then reactivate the moment new food is present. The spores are very resilient and can survive under extreme conditions. Scientists have claimed they found 250 million-year-old spores that are still active [51]. While being spores they are however more vulnerable to external pathogens such as mold. Under ideal conditions though the spores can survive for a long time.

But as long as they stay in the environment of your starter they live in a very protected environment. Other fungi and bacteria have a hard time decomposing your left over starter mass. I have seen only very few cases where the starter actually died. It is almost impossible to kill a starter.

What happens though is that the balance of yeast and bacteria changes in your starter. The bacteria is more fitted to living in an acidic environment. This is a problem when you make another dough. You want to have the proper balance of fluffiness and sour notes. When a starter has hibernated for a long period, chances are that you do not have a desirable balance of microbes. Furthermore, depending on the time your starter hibernated you might only have sporulated microbes left. So a couple of feedings will help to get your sourdough starter into the right shape again.

The following are a couple of scenarios that will help you to conduct proper starter maintenance, depending on when you want to bake the next time.

I would like to bake again the next day:
Simply take whatever starter you have left and feed it again. If you depleted all your starter you can cut a piece of your dough. The dough itself is nothing different than a gigantic starter. I recommend a 1:5:5 ratio like mentioned before. So take 1 piece of

[4] I very often use all my starter to make a dough. So if the recipe calls for 50 g of starter I make exactly 50 g starter in advance. This means I have no starter left. In that case I would proceed to take tiny bit of the dough at the end of the fermentation period. This piece I would use to regrow my starter again.

starter, feed with 5 parts of flour and 5 parts of water. If it is very hot where you live, or if you want to make the bread around 24 hours later after your last feeding, change the ratio. In that case I would go for a 1:10:10 ratio. Sometimes I don't have enough starter. Then I even use a ratio of 1:50:50 or 1:100:100. Depending on how much new flour you feed it takes longer for your starter to be ready again.

I would like to take a break and bake next week:
Simply take your leftover starter and place it inside of your fridge. It will stay good for a very long period. The only thing I see happening is the surface drying out in the fridge. So I recommend drowning the starter in a little bit of water. This extra layer of water provides good protection from the top part drying out. As mold is aerobic it can not grow efficiently under water [15]. Before using the starter again simply either stir the liquid into the dough or drain it. If you drain the liquid you can use it to make a lacto-fermented hot sauce for instance.

The colder it is the longer you preserve a good balance of yeast and bacteria. Generally, the warmer it is the faster the fermentation process is, and the colder it is the slower the whole process becomes. Below 4 °C the starter fermentation almost completely stops. The fermentation speed at low temperatures depends on the strains of wild yeast and bacteria that you have cultivated.

I would like to take a several months break:
Drying your starter might be the best option to preserve it in this case. As you remove humidity and food your microbes will sporulate. As there is no humidity the spores can resist other pathogens very well. A dried starter can be good for years.

Simply take your starter and mix it with flour. Try to crumble the starter as much as possible. Add more flour continuously until you notice that there is no moisture left. Place the flour starter in a dry place in your house. Let it dry out even more. If you have a dehydrator you can use this to speed up the process. Set it to around 30 °C and dry the starter for 12–20 hours. The next day your starter has dried out a bit. It is in a vulnerable state as there is still a bit of humidity left. Add some more flour to speed up the drying process. Repeat for another 2 days until you feel that there is no humidity left. This is important or else it might start to grow mold. Once this is done simply store the starter in an airtight container. Or you can proceed and freeze the dried starter. Both options work perfectly fine. Your sporulated starter is now waiting for your next feeding. If available you can add some silica bags to the container to further absorb excess moisture.

Initially, it would take about three days for my starter to become alive again after drying and reactivating it. If I do the same thing now my starter is sometimes ready after a single feeding. It seems that the microbes adapt. The ones that survive this shock become dominant subsequently.

So in conclusion the maintenance mode you choose depends on when you want to bake next. The goal of each new feeding is to make sure your starter has a desired balance of yeast and bacteria when making a dough. There is no need to provide your starter with daily feedings, unless it is not mature yet. In that case, each subsequent feeding will help to make your starter more adept at fermenting flour.

4

Sourdough starter types

In this chapter of the book we will have a closer look at different sourdough starter types, and their respective traits and usage. They are mostly characterized by their hydration level, and this will provide a trade-off between acidity, volume increase and the gluten level of your flour.

4.1 Introduction

Depending on the flour you have at hand, the type of starter changes. With more bacterial activity you have more gluten consumption of your microbes. So if you want to bake a free standing loaf, you need a flour with more gluten. The more gluten you have, the more of it can be broken down whilst still maintaining dough integrity. If you live in a country where the climate to grow wheat isn't ideal and you only have weaker flours, then a stiff sourdough starter could be advised. The stiff sourdough starter will improve yeast activity and reduce bacterial activity. If you are a chaser of a very sour bread and have a very strong wheat flour then you can try to play with a liquid sourdough starter. The key difference between all of the starters is how much water is used in the starter. The regular starter has a 1:1 relationship of flour to water. The liquid starter has a 5:1 water-to-flour ratio, and the stiff starter has half as much water as flour, as summarized in Table 4.1.

You can change your starter type by just adjusting the feeding ratio of how much flour and water you use. I frequently change my starter type from regular to liquid and then back to a stiff starter. After changing the environment of your microbes, apply feedings at the same ratio over a couple of days so that they can adapt to the new environment. I typically see changes after a single feeding, but I recommend 2 to 3 feedings, one feeding per day, to see a stronger effect.

Your dough is generally just a big sourdough starter. So your starter is going to adapt and regrow inside of your main dough. But you can influence the properties that your starter carries over to your main dough. If you have more bacterial fermentation, then

			Activity	
Starter type	**Hydration (%)**	**Flour type**	**Yeast**	**Bacterial**
Regular	100	Strong wheat	Balanced	Balanced
Liquid	500	Very strong wheat	Minimal	High
Stiff	50–60	All wheat	High	Low

Table 4.1: A comparison of different sourdough starter types and their respective properties. The only difference is the amount of water (hydration) that is used when feeding the starter.

Figure 4.1: Three different starter types next to each other. Note how the liquid starter is submerged in water. It has a hydration of 500 % or more. The regular starter has a hydration of around 100 %, the stiff starter around 50 % to 60 %.

your dough will also have slightly more bacterial fermentation. If you have more yeast fermentation, then your main dough will have slightly more yeast fermentation. This is important to know when you are working with a more mature unfed starter.

Let's say your starter had last been fed 48 hours ago. Chances are that your bacteria are very active while the yeast could be dormant. In such a case you can skip feeding your starter before making another dough. Just use a very tiny amount of starter. For 1 kg of flour I would take around 10 g of starter (1 % in terms of baker's math). If my starter is very young and had just been fed 6 to 8 hours ago I might end up going up to 20 % of starter. As mentioned earlier, remember that your dough is nothing else other than a big starter. It will tremendously help you to figure out your best next steps.

When using such a low inoculation rate (1 %), you need to use stronger flour when making wheat-based doughs. Your flour naturally breaks down due to enzymatic activity. It might take 24 hours for the starter to re-grow inside of your bread dough. At the same time, the enzymatic activity might have caused your gluten to degrade significantly. While this is okay when looking at your starter, your wheat-based dough will flatten out during baking and no longer have the typical characteristics (fluffy crumb structure). A stronger flour with more gluten is thus advised. It allows for a longer fermentation before most gluten is broken down.

4.2 Regular starter

Figure 4.2: A regular sourdough starter at 100 % hydration fed with rye flour.

The regular sourdough starter is made at a hydration of around 100 %. This means the starter has equal parts of flour and water. This is the most common and most universal sourdough starter there is. The starter has a good balance of yeast and bacteria. After a feeding, the volume of the dough greatly increases. After it reaches a certain peak, it will start to collapse again.

The best way to judge whether the starter is ready is to look at signs such as air pockets on the edges of your container. Also use the nose to evaluate the smell of your starter. If you feel that the starter doesn't perform in a desirable way, chances are that your yeast and bacteria ratios are off. In that case frequent daily feedings using a 1:5:5 (starter:flour:water) ratio will help.

A regular starter is a perfect choice to use when utilizing stronger wheat or spelt flours. It also nicely works with rye, emmer or einkorn. If you only have a weak flour at hand with less gluten, this starter might cause issues. As you tend to have quite some bacterial activity, gluten is going to be broken down fast. When using the starter, use around 1 % to 20 % starter based on the flour of your dough.

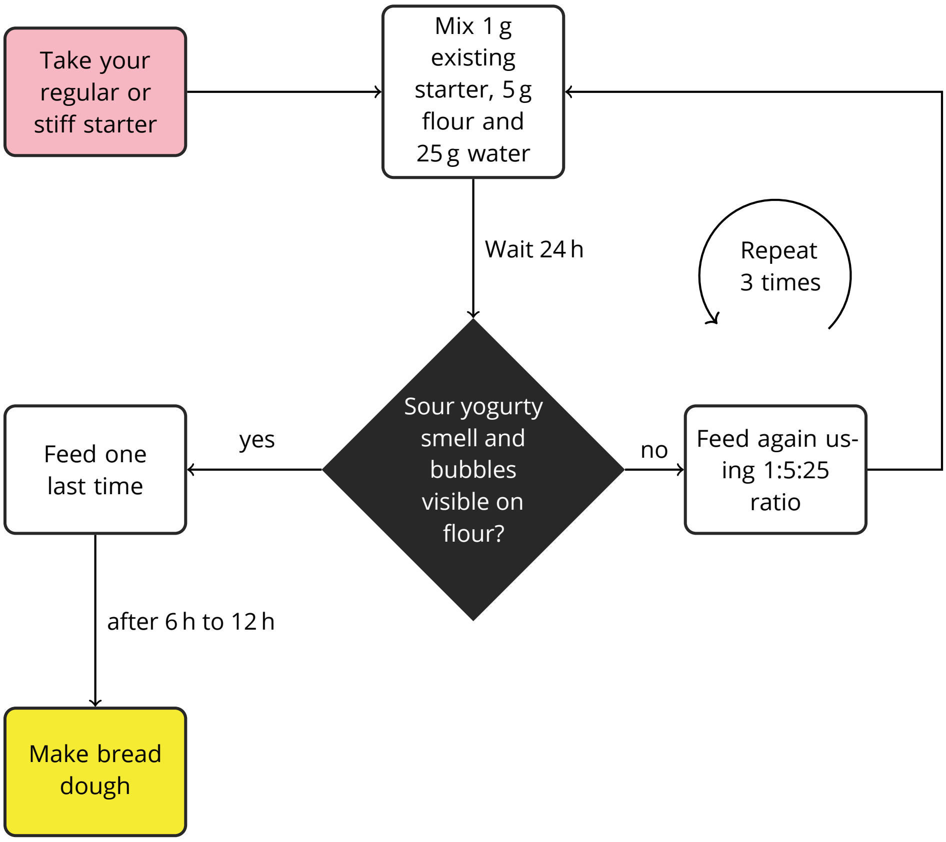
Depending on the bacteria cultivated, a regular starter either has a lactic (dairy), a vinegary (acetic) or mix of both flavor profiles. You can adjust your starter's flavor by changing the type to a liquid starter.

4.3 Liquid starter

Figure 4.3: A liquid sourdough starter features a high level of water. The high water amount boosts lactic acid producing bacteria. After a while the liquid and flour start to separate. Bubbles on the side of the flour indicate that the starter is ready to be used.

The liquid starter is made at a hydration of around 500 %. This means the starter has much more water than flour. The additional layer of water on top of the flour changes the microbiome of your starter.

By introducing this layer of water, less oxygen is available throughout the course of fermentation. This means that your starter will no longer be producing acetic acid. The heterofermentative lactic acid bacteria will thrive in this environment. This is a neat little trick to change your starter's flavor profile from vinegary to lactic. Your starter is going to develop dairy creamy notes. Interestingly, when changing the hydration again, your starter is going to maintain the liquid starter flavor profile, but then benefit again from enhanced yeast activity. The liquid starter conversion is nonreversible. By changing to a liquid starter you will permanently select a subset of microbes that work better in the more liquid environment. So even after going back to a regular or stiff starter the subset of microbes created by the liquid conversion will remain. For this reason, it is recommended to keep a backup of the starter before the liquid starter conversion.



Flowchart 4.1: The process to convert your regular or stiff starter into a liquid starter. The whole process takes around 3 days. The longer you maintain your starter at the suggested hydration level, the more adapted your microorganisms become. It is recommended to keep a backup of your original starter as the liquid environment will select anaerobic microorganisms. This boosts bacteria that create lactic acid rather than acetic acid. The resulting acidity will be perceived as milder. When beginning with a liquid starter your stiff starter will feature mild dairy notes. When beginning this process with a regular starter your created stiff starter will feature both dairy and vinegary notes.

To begin with the conversion, simply take around 1 g of your starter, mix with 5 g flour and 25 g water. Stir everything together properly. After a few minutes the flour is going to start settling in at the bottom of your jar. Repeat this process over a few days. Shake the starter gently to see if you can see tiny CO_2 bubbles moving in the liquid. This is a good sign that your starter is ready. Use your nose to smell the starter. It should have a creamy dairy flavor note.

As you have more bacterial activity, this starter works best with a very strong flour that can withstand a long fermentation period. Using this starter with a weak wheat flour will not work. If you do not care about baking a freestanding loaf, then you can easily use this starter together with a loaf pan. This starter also works great when making a hearty pancake dough. To use it I shake the starter container until I see all ingredients are homogenized. Then I use around 5 % of it in terms of baker's math. So for 1000 g of flour that's around 50 g of liquid starter. As it is very liquid you have to include the 50 g in your liquid calculation. I typically treat the starter directly as liquid in the recipes. So if the recipe calls for 600 g of water and I use 50 g of starter, then I would proceed and only use 550 g of water.

This type of starter is also an excellent mold combatant. As you are removing oxygen from the equation, aerobic mold cannot properly grow. If your starter has a mold problem then the liquid conversion could be the remedy. Take a piece of your starter where you suspect mold growth. Apply the conversion as mentioned before. The mold will likely sporulate as it runs out of food. With each new feeding you are reducing the mold spores. The spores can no longer reactivate as they cannot do so in the anaerobic conditions.

The liquid on top of your starter is an excellent resource that you could use to make sauces. If you feel you would like to add a little bit of acidity, drain the liquid part on your starter and use it. I have used it numerous times to make lacto-fermented hot sauces.

4.4 Stiff starter

The stiff starter is the driest of all the starters. It has a hydration of around 50 % to 60 %. So for 100 g of flour you are using around 50 g to 60 g of water. If you can't mix flour and water because the mixture is too dry you need to increase the water quantity. This is often the case when using whole-wheat/rye flour to make your starter. The more bran your flour contains, the more water your flour can absorb. The stiff starter should have a comparable consistency to pasta or pizza dough. When mixing the starter there should be no chunks of flour left. Test placing the starter on your kitchen counter. When lifting it should slightly stick to your counter's surface. This test indicates that you hydrated the flour sufficiently. When the mixture is too dry, the fermentation speed is greatly reduced and the starter will seem inactive. The starter should be much drier than a regular starter, but also not too dry. Refer to figure 4.5 for a visual example of the starter's required hydration level.

In the stiffer environment the yeast thrives more. This means you will have more CO_2 production and less acid production. In my tests this is a game changer especially if you are using weaker gluten flours. The wheat flours in my home country of Germany tend to be lower in gluten. For wheat to build gluten, warm conditions are preferred [39]. When following recipes from other bakers, I could never achieve similar results. When following timings my doughs would simply collapse and become super sticky. Only when I started to buy more expensive wheat flour my results did start to change. As

Figure 4.4: A stiff sourdough starter that I used to make a Stollen dough for Christmas. Note the bubbles on the edge of the container. The dough does not fall out of the jar. The moment the gluten structure breaks down due to fermentation the starter will ultimately fall in the jar.

not everyone can afford these special baking flours and due to their limited availability, I stumbled upon the stiff sourdough starter. I made several tests where I used the same amount of starter and flour. I only changed the hydration between all the starters. I would then proceed and place a balloon on top of each of the jars. The stiff starter jar was clearly inflated the most. The regular starter followed in second place. The liquid starter finished in third place with far less CO_2 production.

I then proceeded and bought a cheap low-gluten cake flour in my nearby supermarket. This flour before had caused me massive headaches in the past. I made a sourdough bread exactly how I would normally do—I had to reduce the hydration a bit as a low gluten flour does not soak up as much water. Then I replaced the starter with the stiff starter. The dough felt amazing and was suddenly able to withstand a much longer fermentation period. The bread had great oven spring and tasted very mild. I am still yet to find a proper scientific explanation why the yeast part of the dough is more active. Maybe it is not. It could also be that the bacteria is inhibited by the lack of water.

When making the stiff sourdough starter, start by using around 50 % water. If you are using a whole-wheat flour, or a strong flour consider going up to 60 %. All the

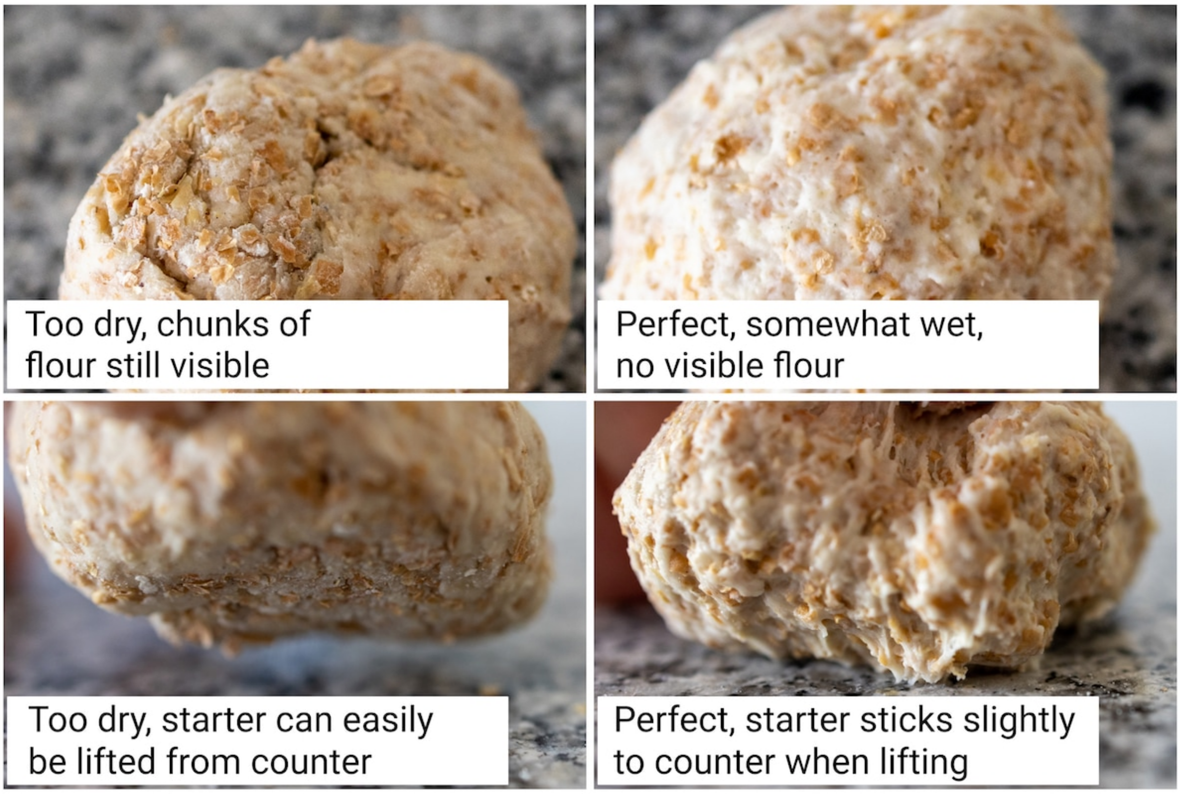
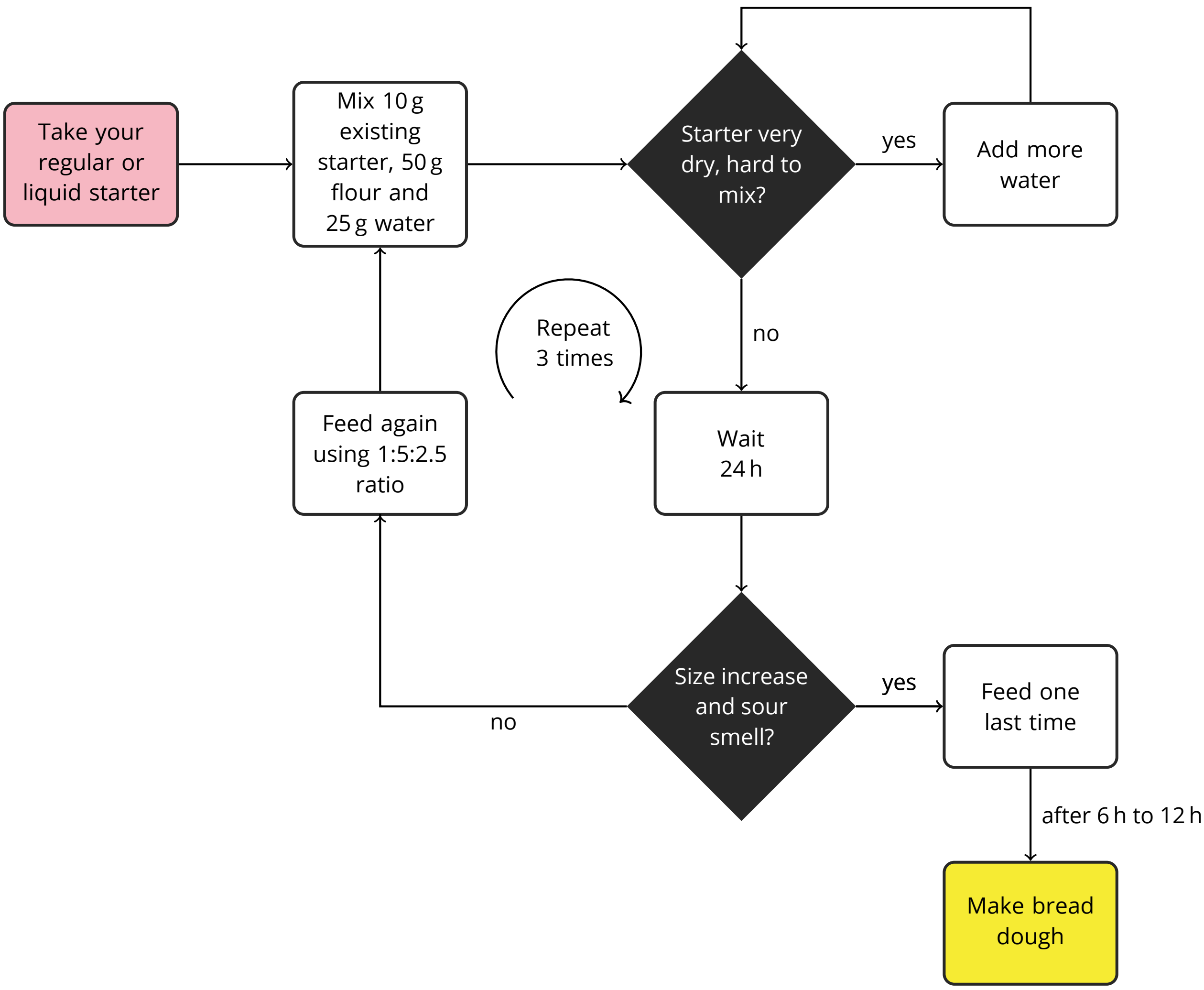


Figure 4.5: An image showing you a stiff starter that is too dry and one that is perfectly hydrated. The starter shouldn't contain chunks of flour and slightly stick to your counter top. The starter in the picture is made with whole-wheat flour.

ingredients should mix together very well. There should be no crumbly flour left. This is a common mistake I have seen when people tried to make the stiff starter. Yes it should be dry, but not to a point where it is a brick of cement. If you have ever made a pasta dough, this dough should feel exactly the same.

To evaluate whether your stiff starter is ready, look for a dome. Also look for pockets of air on the sides of your container. Use your nose to smell the starter. It should have a mild smell. It also tends to smell much more alcoholic than the other starters.

When using a stiff starter, use around 1 % to 20 % starter in terms of baker's math for your dough. This depends on the ripeness of your starter. In summer I typically use around 1 % to 10 % and in winter around 20 %. This way you can also control the fermentation speed. If it is very hot where you live, consider lowering the starter amount to 1 % to 5 %. If it is very cold in your area consider increasing the starter amount up to 30 %. Mixing the stiff starter can be a little bit annoying as it hardly homogenizes with the rest of the dough. In this case, you can try to dissolve the starter in the water you are about to use for your dough. This will make mixing a lot easier.



Flowchart 4.2: The process to convert your regular starter into a stiff starter. The whole process takes around 3 days. The longer you maintain your starter at the suggested hydration level, the more adapted your microorganisms become. The stiff starter boosts the yeast activity of your sourdough starter. The guide uses a 50 % hydration level for the starter. If the dough is too stiff consider increasing this to 60 %.

4.5 Lievito madre or pasta madre

The *lievito madre*, also known as *pasta madre*, belongs to the same category as the stiff sourdough starter. After conducting hours of research, I could not find a difference between *pasta madre* and *lievito madre*. Both terms seem to be used interchangeably in literature.

In many recipes this starter is made directly from dried or fresh fruits. You can also

Figure 4.6: A German Christmas *Stollen* made with a stiff starter instead of yeast.

make a starter from leaves from your garden. As described before, the wild yeast and bacteria consume the glucose from the plants' leaves. All the options work. When making a starter directly from dried fruits, you sometimes lack the bacterial part of the fermentation. The acidity is very important in order to clean your starter from possible pathogens. If you decide to make your starter from fruits, make sure it also acidifies properly when making a dough. A tool such as a pH meter can be of optimal help. Generally, the lower the pH, the higher the acidity. The acidity should be below 4.2 to know that your starter produces sufficient acidity.

Some bakers cleanse the *lievito madre* in a bath of water. This is supposed to remove excess acidity. In my own experiments I have not been able to confirm this methodology. The acidity remains the same. The only reason this could make sense is if you also tried to boost anaerobic microorganisms. However, then the starter would need to remain in this environment for quite some time and not just a few hours.

4.6 Conclusion

Baking with sourdough is simple. It's just flour and water. When seeing a recipe from an experienced baker you wonder, Wait, that's it? There is nothing more to it? I feel that this might be the reason why some bakers have such complicated feeding procedures. They resort to several feedings per day at a certain given ratio. This makes the baker feel a little more elitist. Of course over time as more and more people follow this procedure, it became a self fulfilling prophecy. The more experienced you become, the higher the chances are that a bogus starter feeding guide will reward you with beautiful results. The reason however is not in the starter routine. The reason is that you understand the fermentation better and become better at reading the signs of your dough.

If I had to choose one starter type I would go for the stiff starter. In many cases it will provide you with consistently great results with little effort. In my experience you can make any yeast-based dough and just replace the yeast directly with the stiff sourdough starter. You will be able to achieve even better results with the stiff starter.

Lastly, no matter which starter type you choose, you can control how sour you want your dough to be. The longer you push the fermentation, the more acidity is going to be piled up. The only difference is that for a given volume increase, the stiff starter will produce the least acidity. So for a volume increase of 100 %, the liquid starter has produced the most acidity, followed by the regular starter and then the stiff starter. If you wait long enough, the stiff starter will have produced the same amount of acidity as the other starters. But before doing so it will have also produced a lot more CO_2. If you like the sour flavor, you have to push your fermentation longer. This also means you either need to bake in a loaf pan or have a very strong gluten flour that is able to withstand long fermentation times.

5

Flour types

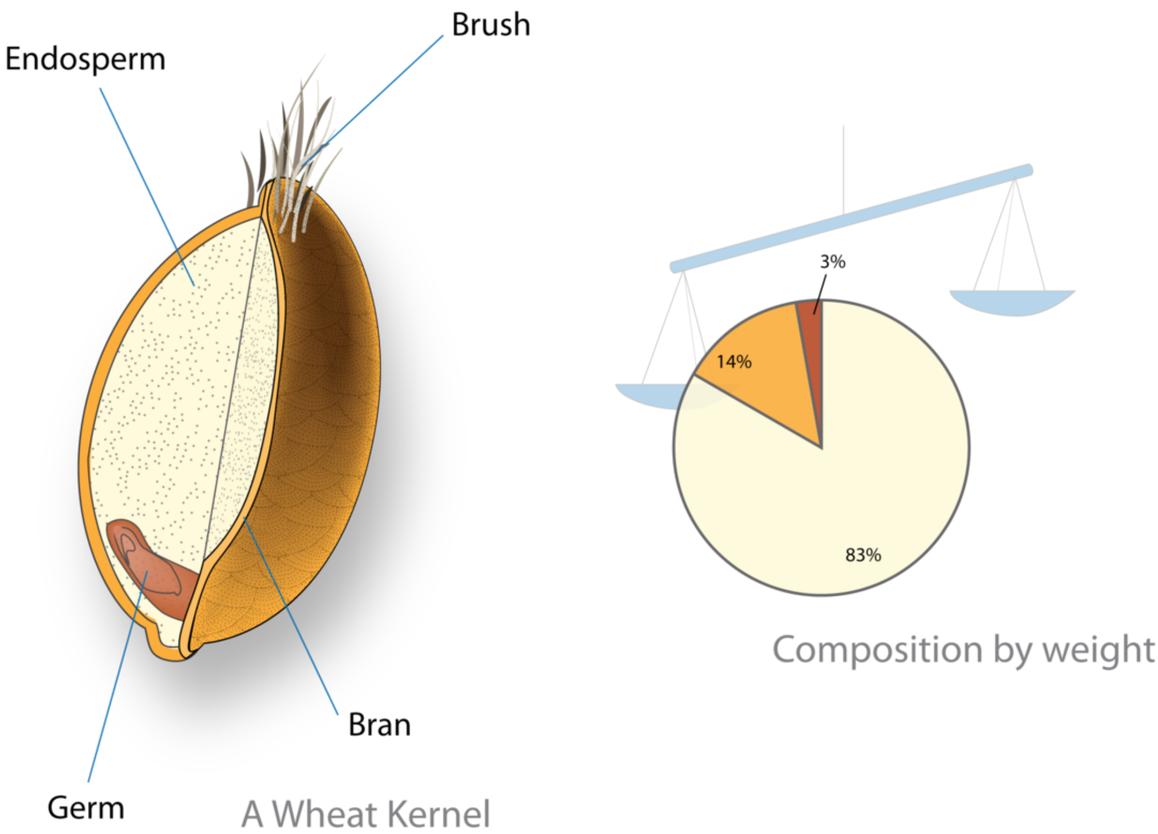
In this chapter we will have a closer look at different flour types and their respective categorization. We will also look at common ways to distinguish different flours of the same type, this way you can more confidently purchase the flour you need.

The most basic flour type is a whole grain flour, in this case the whole seed has been grounded to smaller pieces. Sometimes, depending on what you want to bake, the hearty taste of the bran might not be desired. In this case you can use whiter flours. Together with sieves, mills remove larger parts of the seed's hull. The seed already contains a pre-built germ from the plant waiting to be activated. The whitest flour you can get is mostly just the starch part of the seed. Depending on which layers are still present, different names are used to describe the type of flour.

USA	UK	Germany	France	Italy
Cake	Soft flour	T405	T45	00
All purpose	Plain flour	T550	T55	0
Bread flour	Bread flour	T405 or T550	T45 or T55	00 or 0
		T812	T80	1
		T1050	T110	2
Whole	Whole	Vollkorn	T150	Integrale

Table 5.1: A comparison of how different types of wheat flour are labelled in different countries.

In Germany, the ash content is used to describe the flours. The lab will burn 100 g of flour in the oven. Then afterwards the remaining ash is extracted and measured. Depending on the quantity the flour is categorized. If the flour is of type 405, then 405 mg of ash have remained after burning the flour. The more hull parts the flour has, the more minerals remain, therefore the higher the number, the closer the flour is to



	Carb./g	Protein/g	Fat/g	Fiber/g	Iron (% daily req.)	Others
Bran	63	16	3	43	59	vitamin Bs
Endosperm	79	7	0	4	7	
Germ	52	23	10	14	35	vitamin Bs omega-3/6 lipids

Nutritional Value (per 100g)

Figure 5.1: An overview of a wheat kernel together with its content [18].

whole flour. The numbers are slightly different between each grain type. Generally though, the higher the value, the heartier the taste is going to be.

If you compare different grain types, there are grains with high gluten, low gluten and no gluten. Gluten is what enables bread to have its fluffy consistency. Without gluten the baked goods wouldn't have the same properties. Managing gluten makes the whole bread-making process more complex as more steps are involved.

A dough without gluten doesn't have to be kneaded as the role of kneading is to create the gluten bonds. The more you knead, the stronger they become. With low-gluten and no-gluten flours, you only have to mix the ingredients together, making sure you properly homogenize everything.

During fermentation the gluten degrades as the microorganisms metabolize it. When too much gluten has been converted your dough will no longer have the wheat-like structure previously described. For no/low gluten flour your main focus is managing acidity, you do not want the final bread to be too sour. Conversely you do not have to worry about the gluten degradation, removing a huge headache from the equation.

Grain type	**Homogenize**	**Knead**	**Stretch & Fold**	**Shape**
Spelt, Wheat ($> 70\%$)	Yes	Yes	Yes	Yes
Rye, Emmer, Einkorn, Rice, Corn	Yes	No	No	No

Table 5.2: An overview of different grain types and the steps involved in the respective bread making process.

Because gluten has a special role, the rest of this chapter is dedicated to having a closer look at different gluten flours and how to distinguish them. Like wheat spelt contains significant amounts of gluten, so the same characteristics hold true.

Several recipes call for wheat bread flour, but bread flour can refer to different types of flour. It could be a T405 or a T550 in Germany—this is very often classified incorrectly—the terms *strong* or *bread* flour in this case refer to the properties of the flour. A bread flour is considered to have a higher amount of protein and thus gluten. This flour is excellent when you want to make a sourdough bread as your dough allows for a longer leavening period. As described earlier, the gluten is consumed by your microorganisms. The more gluten you have, the longer your dough keeps its integrity. If you wanted to make a cake, you might want to use a flour with less gluten. The gluten binding properties might not be desirable since the final cake could have a chewy texture.

In conclusion, not every T405, T45 or T00 flour is the same. Depending on the properties of the plant they come from, the flours will have different properties. For that reason some countries like Germany have introduced additional scales to evaluate the quality of the wheat. The category *A* refers to good quality wheat that can be blended with poorer qualities to improve the flour. The category *B* refers to average wheat that can be used to create different baked goods. Category *C* is used for wheat that has poor baking qualities. This could happen, for instance, if the wheat already started to sprout and thus lost some of its desirable baking properties. This type of wheat is typically used in animal feed or as fermentable biomass for generators. Category *E* refers to *Elite* wheat. It's the highest quality of wheat. This kind of wheat can only be harvested when the wheat has grown under optimal conditions. You can compare this to a winery that uses only the best grapes to make a reserve wine. Unfortunately, this is usually not printed on the packaging of the flour that you buy. You can look out for the protein value as a possible indicator. However, large mills blend flours together to maintain quality throughout the years. Blended flour is also not listed on the packaging. It might be that bakeries extract gluten from some flour and then mix it in order to create better baking flours.

In Italy the so-called *W-value* has been introduced to better show how the flour will behave. A dough is made, and then the resistance of this dough to kneading is measured. The more gluten a flour has, the more elastic the dough is, and the more it will resist kneading. A higher W flour will have a higher gluten content and allow for a longer fermentation period. But at the same time, it is also harder for the microbes to inflate the dough as there is more balloon material. To make an excellent fermented product out of a high W flour you will need to have a long fermentation period. The long fermentation period also means that your microbes will enrich your dough with more flavor.

W-Value	**Hydration (%)**	**Uses**	**Fermentation time**
0–150	50	Cookies	Very short
150–250	50–60	Cakes, Bread, Pizza	Short–Medium
250–350	60–70	Bread, Pizza	Long
350+	70–90	Bread, Pizza	Very long

Table 5.3: An overview of different levels of W-values and the respective hydrations and fermentation times.

Generally, when aiming to bake free standing sourdough bread, aim for a higher protein content. If the gluten value is relatively low, your bread will collapse faster. Baking bread is still possible, but it might be easier to use other techniques such as a loaf pan, to consider skillet bread or flatbread.

An additional, rarely considered characteristic of good flour is the level of damage to the starch molecules. This is a common problem when you are trying to mill your own wheat flours at home. The chances are that your home mill is not able to achieve the same results a larger mill can. The damaging of the starches is essential to improve the properties of the dough. You will have better gelatinization and water absorption with properly damaged starch [12]. As more starch is damaged, the surface area increases. This improves how water interacts with the flour. This also provides a larger surface that your microbes can use to attack the molecules and start the fermentation process.

I am still yet to find a good way of milling my own wheat flour at home. Even after trying to mill the flour 10 times with short breaks, I was not able to achieve the same properties as with commercially milled flour. The doughs I would make felt good, maybe a bit coarse. However, during baking the doughs would start to de-gas quickly and turn into very flat breads. I have had great success though when utilizing home-milled flour together with a loaf pan or as a pan bread. If you have found great ways to work with home-milled flour, please reach out. The potential of using home-milled flours is huge. It would enable even distant communities to grow their own wheat and be able to produce amazing freshly baked bread.

6 Bread types

In this chapter you will learn about different bread types and their advantages and disadvantages. You can also find very simple recipes for flatbread and pan loaf. The former is probably the most accessible, least effort type of bread you can make, while the latter is a little more involved. Free standing bread has its own chapter, due to its increased complexity.

6.1 Introduction

In this section we classify bread by its baking techniques. The appearance and taste will of course be different, but you can get excellent bread with each of them. Some breads will require investment and technique, as depicted in Table 6.1. Flatbread is probably the most accessible, least effort type of bread you can make. If you are a busy person and/or don't have an oven, this might be exactly the type of bread you should consider.

	Type of bread		
	Flat	**Loaf pan**	**Free standing**
Cooking method	Pan, fire, barbecue	Oven	Oven
Working time	3 min.	5 min.	60 min.
Flour types	All	All	Gluten flours
Difficulty	Very easy	Easy	Difficult
Cost	Low	Medium	High

Table 6.1: An overview of different bread types and their respective complexity.

6.2 Flatbread

Flatbread is probably the simplest sourdough bread to make. To make a flatbread no oven is required; all you need is a stove.

Figure 6.1: An assorted selection of different flatbreads made with sourdough. From left to right: Wheat tortilla, rye, spelt and corn.

This type of bread is super simple to make as you can skip a lot of the technique that is normally required to make wheat doughs. The flatbread can be made with all kinds of flours. You can even use flour without gluten, such as corn or rice flour, to make the dough. To make the flatbread a little more fluffy, you can use a little bit of wheat flour. The developing gluten will trap the gases. During baking, these gases will inflate the dough.

Another trick to improve the texture of the flatbread is to make a very wet dough. A lot of the water will evaporate during the baking process and thus make the bread fluffier. If your water content is very high, it will produce a pancake-like consistency, as you can see in Table 6.2

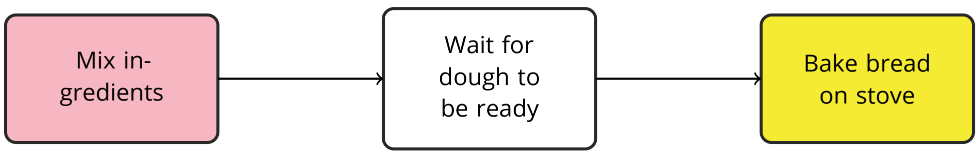
For a full recipe including the process of making such a flatbread, refer to Subsection 6.2.2

	Flat breads	Pancakes
Flour	100 g	100 g
Water	up to 100 g (100 %)	300 g (300 %)
Sourdough starter	5–20 g (5–20 %)	5–20 g (5–20 %)
Salt	2 g (2 %)	2 g (2 %)
Bake when?	Dough increased 50 % in size	Bubbles visible on surface

Table 6.2: Flatbread or pancake recipe for 1 person. Multiply the ingredients to increase portion size. Refer to the Section 3.1 "Baker's math" to learn how to understand and use the percentages properly.

6.2.1 Flatbread framework

As explained above, if you are just getting started, making a flatbread is the easiest way to start making great bread at home. With just a few steps, you can stop buying bread forever. This works with any flour, including gluten-free options.



Flowchart 6.1: The process of making a flatbread is very simple, requiring very little effort. This type of bread is especially handy for busy bakers.

This is my go-to recipe that I use to make bread whenever I have little time or when I am abroad. You can choose between two options:

1. A flatbread similar to a roti or naan bread
2. Sourdough pancakes.

To get started prepare your sourdough starter. If it has not been used for a very long time, consider giving it another feed. To do so, simply take 1 g of your existing sourdough starter and feed it with 5 g of flour and 5 g of water. If you do this in the morning, your sourdough starter will be ready in the evening. The warmer it is, the sooner it will be ready, consider using warm water if it is very cold where you live.

This way you should have around 11 g of sourdough ready in the evening. You will have the perfect quantity to make a dough for one person. In case you want to make more bread, simply multiply the quantities shown in Table 6.2.

Then in the evening simply mix the ingredients as shown in the table. Your dough is going to be ready in the morning. It's typically ready after 6–12 hours. If you use more sourdough starter it will be ready faster, conversely it will take longer if you use less. Try to aim for a fermentation time of 8–12 hours as by using your dough too soon, the

Figure 6.2: A flatbread made with purely wheat flour. The dough is drier at around 60 % hydration. The drier dough is a little harder to mix. As wheat contains more gluten, the dough puffs up during the baking process.

flavor might not be as good. By using your dough later it might become a little more sour. The best option is to experiment and see what you personally like the most.

After mixing the ingredients together cover the container, this prevents the dough from drying out and makes sure no fruit flies get access. A transparent container will be helpful when getting started. You can observe the dough more easily and see when it is ready.

If you used the flatbread option with less water, look at the size increase of your dough. It should have increased at least 50 % in size. Also look out for bubbles on the sides of your container.

When using the pancake recipe, look out for bubbles on the surface of your dough. In both cases use your nose to check the scent of your dough. Depending on your sourdough starter's microbiome your dough will have dairy, fruity, alcoholic notes or vinegary, acetic notes. Relying on the smell of your dough is the best way to judge whether your dough is ready or not. Timings are not reliable as they depend on your starter and the temperature. If your dough is ready too soon, you can now move it directly to the fridge and bake it at a later, more convenient time. The low temperature

Figure 6.3: An Ethiopian woman baking an *injera* made using teff flour. The image has been provided by Charliefleurene via Wikipedia.

will halt the fermentation process[1] and your dough will last for several days. The longer you wait, the more sour the bread is going to be. The fridge is a great option in case you want to take the dough with you when visiting friends. People are going to love you for the freshly baked flatbreads or pancakes. If you dare, you can also taste a little bit of your raw uncooked dough. It is likely going to taste relatively sour. I do this frequently to better evaluate the state of my doughs.

If you are feeling lazy or don't have time, you could also use older sourdough starter to make the dough directly without any prior starter feedings. Your sourdough starter is going to regrow inside your dough. Remember that the final bread might be a bit more on the sour side as the balance of yeast to bacteria could be off. In the Table 6.2 I recommended using around 5 % to 20 % of sourdough starter based on the flour to make the dough. If you were to follow this approach, just use around 1 % and make the dough directly. The dough is probably going to be ready 24 hours later, depending on the temperature.

If you want to make sweet pancakes, add some sugar and optional eggs to your dough

[1]There are some exceptions. In some rare cases your starter might also work at lower temperatures. You might have cultivated microbes that work best at low temperatures. Nevertheless, fermentation is always slower the colder it gets. A fridge really helps to preserve the state of your dough.

Figure 6.4: A sourdough pancake made with teff flour. The pockets come from evaporated water and CO_2 created by the microbes. The image has been provided by Łukasz Nowak via Wikipedia.

now. A good quantity of eggs is around one egg per 100 g of flour. Stir your dough a little bit and it will be ready to be used. You'll have delicious sweet savory pancakes, the perfect combination. By adding the sugar now, you make sure that the microbes don't have enough time to fully ferment it. If you had added the sugar earlier, no sweet flavor would be left 12 hours later.

To bake your dough heat your stove to medium temperature. Add a little bit of oil to the pan. This helps with heat distribution and ensures even cooking. With a spatula or a spoon place your dough in the pan. If your dough was sitting in the fridge, bake it directly. There is no need to wait for your dough to come to room temperature. If you have a lid, place it on your pan. The lid helps to cook your dough from the top. The evaporating water will circulate and heat up the dough's surface. When making a flatbread, make the dough around 1 cm thick. When using the pancake option, opt for around 0.1 cm to 0.5 cm depending on what you like.

After 2–4 minutes flip over the pancake or flatbread. Bake it for the same time from the other side. Depending on what you like, you can wait a little longer to allow the bread to become a bit charred. The longer you bake your bread, the more of the acidity is going to evaporate. If your dough is a bit more on the sour side, you can use this trick to balance out the acidity. This really depends on which flavor you are looking for.

When making a flatbread I recommend wrapping the baked flatbreads in a kitchen

Figure 6.5: The crumb of a flatbread made with einkorn as flour. Einkorn is very low in gluten and thus does not trap as much CO_2 as a wheat based dough. To make the dough fluffier use more water or consider adding more wheat to the mix of your dough.

towel. This way more of the evaporating humidity stays inside of your bread, making sure your flatbreads stay nice and fluffy for a longer period after the bake. A similar strategy is used when making corn tortillas.

You can safely store the baked flatbreads or pancakes in your fridge for weeks. When storing make sure to store them in an airtight plastic bag so that they do not dry out. If they dry out, spray them with some water and toast them. They will be almost as good as when they were freshly baked.

Keep a little bit of your unbaked dough. You can use it to make the next batch of bread or pancakes for the next day. If you want to bake a few days later, add a little bit of water and flour and store this mixture in your fridge for as long as you like.[2]

6.2.2 Simple flatbread recipe

By following the steps outlined in this section, you'll be introduced to a versatile bread that's perfect for a myriad of culinary applications. Whether you're scooping up a savory dip, wrapping a flavorful filling, or simply enjoying a piece with a drizzle of olive oil, these flatbreads are sure to impress.

[2]The starter will stay good for months. If you expect to leave it longer, consider drying a little bit of your sourdough starter.

Ingredients

400 g	(100 %)	Flour (wheat, rye, corn, whatever you have at hand)
320 g	(80 %)	Water, preferably at room temperature
80 g	(20 %)	Active sourdough starter
8 g	(2 %)	Salt

Instructions

Prepare the dough

In a large mixing bowl, combine the flour and water. Mix until you have a shaggy dough with no dry spots.

Add the sourdough starter and salt to the mixture. Incorporate them thoroughly until you achieve a smooth and homogenized dough.

Fermentation:

Cover the bowl with a lid or plastic wrap. Allow the dough to rest and ferment until it has increased by at least 50 % in size. Depending on the temperature and activity of your starter, this can take anywhere from 4 to 24 hours.

Cooking preparation:

Once the dough has risen, heat a pan over medium heat. Lightly oil the pan, ensuring to wipe away any excess oil with a paper towel.

Shaping and cooking:

With a ladle or your hands, scoop out a portion of the dough and place it onto the hot pan, spreading it gently like a pancake.

Cover the pan with a lid. This traps the steam and ensures even cooking from the top, allowing for easier flipping later.

After about 5 minutes, or when the bottom of the flatbread has a golden-brown crust, carefully flip it using a spatula.

Adjusting cook time. If the flatbread appears too dark, remember to reduce the cooking time slightly for the next one. Conversely, if it’s too pale, allow it to cook a bit longer before flipping.

Cook the flipped side for an additional 5 minutes or until it’s also golden brown.

Storing:

Once cooked, remove the flatbread from the pan and place it on a kitchen towel. Wrapping the breads in the towel will help retain their softness and prevent them from becoming overly crisp. Repeat the cooking process for the remaining dough.

Serving suggestion:
Enjoy your sourdough flatbreads warm, paired with your favorite dips, spreads, or as a side to any meal.

6.3 Loaf pan bread

Loaf pan bread is made using the help of a special loaf pan or loaf tin. The edges of the pan provide additional support for the dough to rise. Making a bread using a loaf pan requires an oven.

Figure 6.6: A freestanding bread and a wheat loaf pan bread. Both of them received a small incision before baking which helps to control how they open up.

After mixing your dough, you can place it directly into the loaf pan. This makes the whole process simpler since you can skip steps such as shaping the dough.

To make a great loaf pan bread with little work:

1. Mix the ingredients of your dough (gluten free works too)
2. Place into the loaf pan
3. Wait until your dough has roughly doubled in size

4. Bake in a non pre-heated oven for around 30–50 minutes

Knowing the exact baking time is sometimes a little challenging as it might be that the outside of your bread is cooked but the inside is still raw. The best way is to use a thermometer and measure the core temperature. At around 92 °C (197 °F) your dough is done. I generally bake loaf pan bread at around 200 °C (390 °F), which is a little less than my freestanding bread which I bake at 230 °C (445 °F). That's because it takes a while for the dough to bake properly inside the loaf pan. The edges don't heat up as quickly. Then the top part of the dough is properly cooked, while the inside isn't yet. When baking make sure to use steam or simply place another equally sized loaf pan on top of your loaf pan. This way you simulate a Dutch oven. The dough's evaporating moisture will stay inside.

A good trick to make excellent loaf pan bread is to make a very sticky dough. You can opt for a hydration of 90 % to 100 %, almost resembling a default sourdough starter. Just like with flatbread, the high humidity helps to make a more airy, fluffy crumb. The bread will also be a bit chewier. This type of bread made with rye is my family's favorite style of bread. The hearty rye flavor paired with the sticky consistency really makes an excellent sandwich bread.

To improve the structure you can also consider using around 50 % wheat flour in your mix. The gluten network will develop as your dough ferments and allow for more gas to be trapped in the dough.

A common problem you will face when making a loaf pan bread is the dough sticking to the pan. Use a generous amount of oil to grease your pan. A nonstick vegetable oil spray can do wonders. Don't clean your loaf pans with soap. Just use a kitchen towel to clean them. With each bake a better patina forms, making your pan more and more stick resistant.

What's amazing about this type of bread is that it works with every flour. The overall time to work the dough is probably less than 5 minutes, making it very easy to integrate into your daily routine. Furthermore, loaf pans use the space in your oven very efficiently. Using pans I can easily bake 5 loaves at the same time in my home oven. Normally I would need multiple baking sessions for freestanding loaves.

6.4 Free standing bread

A freestanding loaf is baked entirely without supporting baking vessels in your oven. To make a freestanding loaf more steps and tools are required.

When using wheat, make sure to mix your dough enough to develop a gluten network. Allow the dough to reach a certain size increase during the fermentation. Afterward, divide and pre-shape the dough into the desired visual shape you would like. Each

Figure 6.7: A freestanding sourdough bread. Note the incision known as an *ear* and the oven spring clearly distinguish this type of bread from flatbread and loaf pan bread.

shape requires a different technique. Sometimes achieving the right shape can be challenging. Making a baguette, for instance, requires performing more steps. Mastering this technique takes several attempts.

Once the dough is shaped, it is proofed again for a certain period of time. Once the dough is ready, a sharp tool such as a razor blade is used to make an incision into the dough. This helps control how the dough opens up during the baking process.

All these steps require practice. Each of them has to be performed perfectly, without mistakes. But after baking you will be rewarded with a beautiful bread with great taste and consistency.

There is a dedicated recipe and tutorial for this type of bread in the Wheat sourdough chapter.

7

Wheat sourdough

In this chapter, you will learn how to make freestanding wheat sourdough bread.

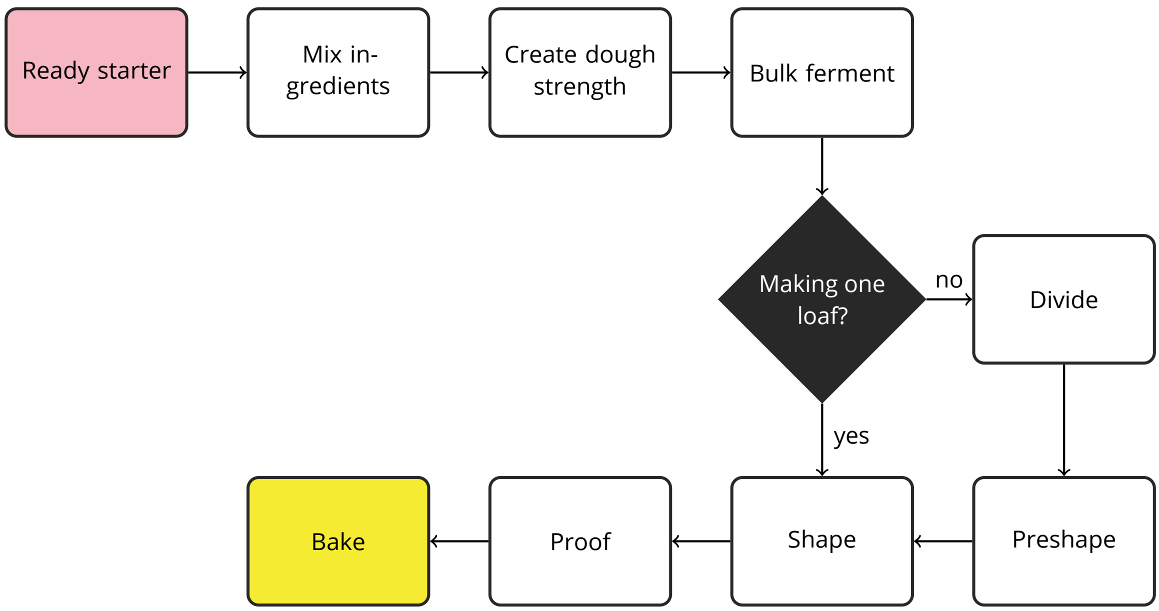
Figure 7.1: A freestanding sourdough bread next to bread made in a loaf pan. Freestanding sourdough is considered the supreme discipline of sourdough bread by many bakers.

Freestanding sourdough bread is my favorite type of bread. It combines a great crunchy crust, superb flavor, and a soft fluffy crumb. This is the type of bread that is being inhaled by my friends and family. Unfortunately, making this type of bread requires a lot more effort, patience, and technique than other types of bread. You have to perfectly balance the fermentation process. You cannot ferment for too short and also not for too long. The techniques you need to learn also require a bit more skill. It took me several attempts to get this right. I faced several challenges: I had the wrong flour. I didn't properly know how to use my oven. When should I stop the fermentation? There is a lot of information out there. I dug through most of it and have tried almost everything. In many cases the information was wrong; in other cases, I found another valuable puzzle piece. Aggregating all this information was one of my main motivations to start `The Bread Code`. My key learning was that there is no recipe that you can blindly follow. You will always have to adapt the recipe to your locally available tools and environment.

But do not worry. After reading this chapter you will know all the signs to look out for. You will be able to read your dough. You will turn into a confident hobby baker who can bake bread at home, at high altitudes, at low altitudes, in summer, in winter, at your friend's place, and even on vacation. Furthermore, you will know how to scale your production from 1 loaf to 100 loaves of bread. If you ever wanted to open up a bakery, consider this knowledge to be your foundation.

Mastering this process will enable you to make amazing bread that tastes much better than any store-bought bread.

7.1 The process



Flowchart 7.1: The typical process of making a wheat-based sourdough bread.

The whole process of making great sourdough bread starts with readying your sourdough starter. The key to mastering this process is to manage the fermentation process properly. For this, the basis is to have an active and healthy sourdough starter.

Once your starter is ready, you proceed to mix all the ingredients. You want to homogenize your sourdough starter properly. This way you ensure an even fermentation across your whole dough.

After a short break, you will proceed and create dough strength. Kneading will create a strong gluten network. This is essential to properly trap the CO_2 created during the fermentation.

Once you've kneaded, the bulk fermentation starts. It is called bulk fermentation because you typically ferment multiple loaves together in one bulk. Understanding when to stop this step will take some practice. But nothing to worry about, you will learn the exact signs to look out for.

Once this is completed you need to divide your large blob of dough into smaller pieces and pre-shape each piece. This allows you to apply more dough strength and shape more uniform loaves.

The proofing stage follows where you finish the fermentation process. Depending on your time you can proof it at room temperature or in the fridge. Mastering proofing will turn your good loaf into a great loaf.

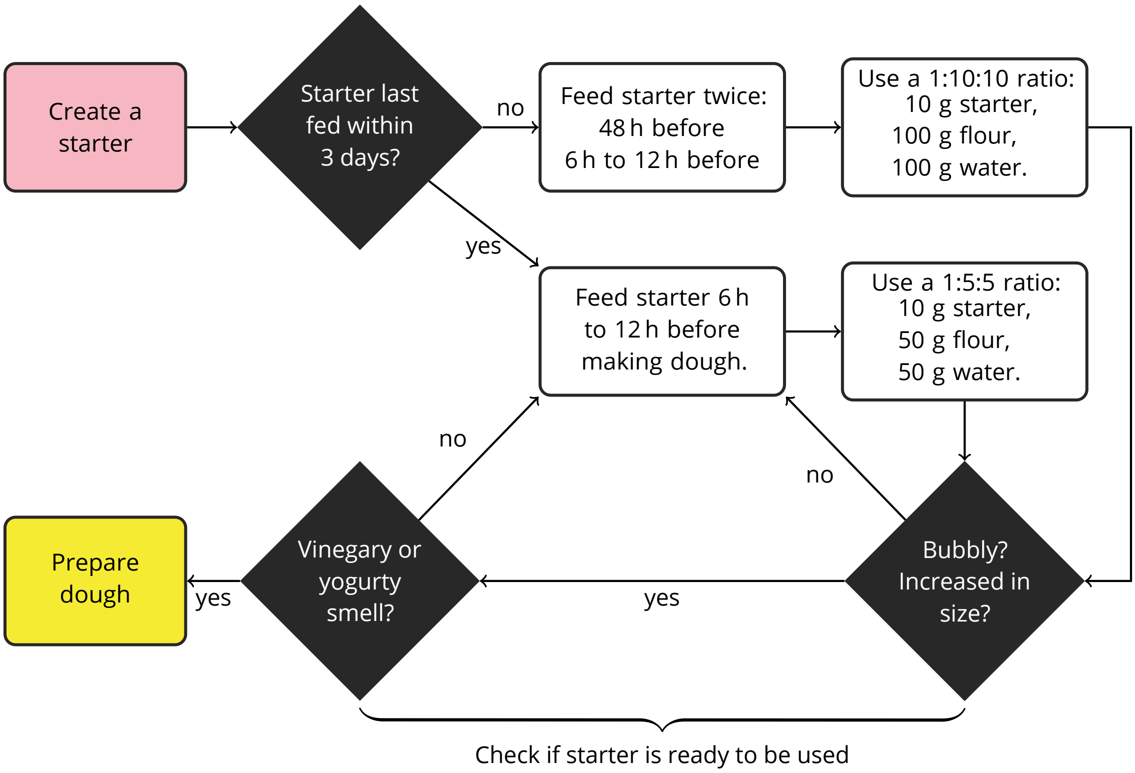
Lastly, you will finish the whole process by baking. You will learn different options on how to properly steam your dough. This way your dough will have a beautiful oven spring. During the second stage of the baking process, you will finish building your crust.

All the steps rely on each other. You will need to get each of the steps right to make the perfect bread.

7.2 Readying your starter

The most crucial part of the bread-making process is your starter. The starter is what starts the fermentation in your main dough. If your starter is off, then your main dough is also going to cause trouble during the fermentation. Your starter's properties are passed on to your main dough. If your starter doesn't have a good balance of yeast to bacteria, so will your main dough.

Generally, think of the dough you are mixing as a big starter with salt. After mixing all the ingredients, you have a green field environment again. The yeast and bacteria start to fight again to outcompete each other. There is plenty of food available, and they all do their best to win. Depending on the starter you mix into your dough, some of the microorganisms might have an advantage over others.



Flowchart 7.2: The process to check your sourdough starter when making wheat-based doughs. In practice I frequently use a stiff sourdough starter. The stiff starter features enhanced yeast activity. In that case, you can use the same ratios as shown in the chart except for the water quantity. The stiff starter has a hydration of 50 % to 60 %. So you would have half the shown water quantities, i.e., if the chart shows 100 g of water, use 50 g to 60 g of water for your stiff starter.

The first option to achieve a good balance is to apply feedings. If your starter hasn't been fed in a long period, the bacteria dominate. This happens if your starter has been sitting unused in the fridge, for instance. As more and more acidity piles up, the environment is becoming more and more hostile to the yeast. The lactic acid bacteria tolerate this environment better. Your dough fermentation would be more on the bacterial side with this starter. By applying a couple of feedings, the yeast becomes more active. The older your starter, the more acid resistant the yeast becomes. Initially, I had to feed my starter 2–3 times to fix the balance. With my more mature starter, one feeding seems to be enough to balance the microorganisms.

Some people use a 1:1:1 ratio to refresh the starter. This would be one part of the old starter (10 g for instance), 1 part of flour, and one part of water. I think this is utter rubbish. As mentioned your starter is a miniature dough. You would never opt for a 1:1:1 ratio to make dough. You might use a maximum of 20 % starter to make dough. That's why I advocate using a 1:5:5 ratio or a 1:10:10 ratio depending on how ripe your starter is. As I almost always use a stiffer sourdough starter due to its enhanced yeast fermentation advantages (see Section 4.4) my ratio is never 1:5:5. My ratio would be 1:5:2.5 (1 part old starter, 5 parts flour, 2.5 parts water). If it is very warm where you live you could opt for the aforementioned 1:10:5 or 1:20:10. This way you slow down the ripening of your starter. You can also use this trick to make starter feeding work with your schedule. If your starter is typically ready in 6 hours but today you need it ready later, simply increase how much flour/water you feed your starter. These are all values that you need to experiment with on your own. Every starter is unique and might behave slightly differently.

The second option at your disposal is the starter quantity that you use to make the dough. As previously stated your starter regrows inside of your main dough. While I would normally use 10 % to 20 % of starter based on the flour, sometimes I go as low as 1 % starter. This way the microorganisms have more room to balance out while fermenting the dough. If my sourdough starter has not been fed in a day, I might use 5 % of sourdough to make a dough. If I push this to 2 days without feedings, I lower the starter amount even further. I would opt for the previously mentioned 1 % starter. If the food is very scarce, your microorganisms will sporulate. They need to regrow again from the spores they created. In this hibernation state, it takes longer for them to become fully active again. I have tried several times to make dough directly out of a dry starter. I wasn't successful because the fermentation took too long. The microorganisms had to regrow from spores and then begin the fermentation. As explained earlier there is a limit to fermentation times as your dough naturally breaks down. Furthermore, you want your microorganisms to outcompete other pathogens contained in the flour. The less starter you use, the easier it is for them to reproduce. A strong starter will outcompete other germs. While the method of reducing the starter works, I recommend Option 1 more. It will reliably create better bread. Option 2 is typically what I use when I fed my starter in the morning but didn't manage to make a dough in the evening. I don't want to feed my starter again the next morning. I would like to make a dough directly without waiting and thus use less of the very ripe starter.

Over time you will become more accustomed to your starter and how it behaves. You will be able to read the signs of its activity and judge its state.

7.3 Ingredients

All you need to make great sourdough bread is flour, water, and salt. You can of course add additional things to your dough such as seeds. I personally enjoy the hearty taste of whole-wheat. Thus I like to add around 20 % to 30 % of whole-wheat flour to the mix. You could also make this recipe with 100 % whole-wheat flour directly. In this case, look out for strong whole-wheat flour that is made from flour with higher protein. If you don't like whole-wheat you can omit the flour from the recipe. Simply replace the listed quantity with bread flour. One thing to consider about whole-wheat flour is its increased enzymatic activity. By adding some whole-wheat flour you will speed up the whole fermentation process.

Especially when getting started I recommend using bread flour which contains more gluten than all-purpose or cake flour. This is essential when trying to bake a freestanding loaf with sourdough.

Find below an example recipe for 1 loaf including baker's math calculation:

- 400 g of bread flour
- 100 g of whole-wheat flour
- *Total: 500 g of flour*
- 300 g to 450 g of room temperature water (60 % up to 90 %). More on this topic in the next chapter.
- 50 g of stiff sourdough starter (10 %)
- 10 g of salt (2 %)

In case you want to make more bread simply increase the quantities based on how much flour you have. Let's say you have 2000 g of flour available. The recipe would look like this:

- 1600 g of bread flour
- 400 g of whole-wheat flour
- *Total: 2000 g of flour*, equaling 4 loaves
- 1200 g up to 1800 g of room temperature water (60 to 90 %)
- 200 g of stiff sourdough starter (10 %)
- 40 g of salt (2 %)

This is the beauty of baker's math. Simply recalculate the percentages, and you are good to go. If you are unsure about how this works, please check out the full Section 3.1 which looks at the topic in detail.

7.4 Hydration

Hydration refers to how much water you use for your flour. When beginning to make bread, I always got this wrong. I followed a recipe from the internet, and my dough never looked like the dough shown in the recipe. The amount of water your flour requires is not fixed. It depends on the flour you have.

When a seed gets into contact initially, the outer layers soak up the water. That's why when using whole-wheat (still containing these layers) you have to use a little bit more water.

By forming gluten strands, water is absorbed into your dough's gluten matrix. The higher the protein value, the more water can be used.

Some bakers like to use highly hydrated doughs to create fluffier bread.[1] The reason for this is the dough's improved extensibility. The wetter the dough, the easier it is for the dough to be stretched. When you pull it, the dough will hold its shape. In comparison, a very stiff (low hydration) dough will maintain its shape for a longer period. To visualize this, think of your extensible dough as a balloon. The stiff dough is like a car tire. The yeast has a much harder time inflating the car tire compared to the balloon. That's because the rubber of the car tire is much less extensible. It requires much more force to inflate the tire. For this reason, an extensible dough will inflate more in the oven. The loaf will be visually bigger and offer an airier more open crumb structure.

While this might sound great, the high hydration causes several side effects.

1. Your dough becomes more difficult to handle. Your dough will be stickier.
2. Your dough has to be kneaded for longer to build a proper gluten network.
3. During the fermentation your dough might become too extensible and lose some of the dough strength. To circumvent this, stretch and folds are applied compared to regular dough, requiring you to invest a lot more work.
4. Shaping becomes much more of a hassle as the dough is very sticky.
5. The dough can stick to the banneton a lot easier while proofing.
6. If you wait too long during proofing, the dough won't have enough strength left to pull upwards and will stay flat.
7. Generally, the higher the water content, the more bacterial fermentation you have. Thus a wetter dough will reduce gluten faster than a stiffer dough. This is why you have to start the fermentation with a sourdough starter in perfect shape.

[1] Sometimes it almost feels like a comparison of skill value between bakers. The more water they can handle, the more skillful the baker.

Bakers use a process called autolysis to shorten the main fermentation time to circumvent this.

8. The crumb, in the end, might be perceived as somewhat sticky. It still contains a lot of water. I love this crumb, but this comes down to personal taste.

To achieve a high-hydration dough, it is best to slowly add water to your dough. Start with 60 % hydration, then slowly add a bit more water. Knead again until the water is absorbed. Repeat and add more water. As your dough has already formed a gluten network, new water can be absorbed much easier. You will be surprised by how much water your dough can soak up. This method is commonly known as the bassinage method. More on that later. By opting for this technique, I was easily able to push a low-gluten flour to a hydration of 80 %. This is also my method of choice when making dough now. I keep adding water until I can feel that the dough has the right consistency. As you bake more bread, you will develop a better look and feel for your dough. When mixing by hand this can be quite cumbersome. It is a lot easier when using a stand mixer.

All in all, increasing hydration requires a lot of trial and error. There is however one option that makes things easier and causes fewer headaches: Slow fermentation. You get the same extensibility advantages the high hydration offers by simply letting your dough ferment for a longer period. Slowing the fermentation process is easy. Use less sourdough starter or ferment in a cooler environment.

There are two reasons for the slow fermentation advantages. As explained earlier, both the protease enzyme and bacteria break down your gluten network. So as fermentation progresses, your dough will automatically become more extensible. This is because the rubber layers of your car tire are slowly converted and eaten. Ultimately your car tire turns into a balloon that can very easily be inflated. When waiting too long, the balloon will burst. You will have no gluten left anymore, and your dough becomes very sticky. Finding the sweet spot of enough rubber eating and not too much is what the perfect wheat sourdough bread is about. But don’t worry — after reading this chapter you will have the right tools at your disposal.

The advantages of slow fermentation can be nicely observed when experimenting with a fast-fermenting yeast dough (1 % dry yeast based on flour). The crumb of such a dough is never as open as a dough made with sourdough. Furthermore, the protease enzyme cannot do its job within such a short fermentation period. Large industrial bakeries add active malt which contains a lot more enzymes. This way the time required to make the dough is shortened. You will most likely find malt as an ingredient in supermarket bread. It is a great hack. The baked turbo fermentation bread will feature a relatively dense and not fluffy crumb. That is because only very little gluten is broken down when finishing the fermentation period in 1 hour. If you were to slow things down, the dough would look completely different. Try this again and use much less yeast. This is the secret of Neapolitan pizza. Only a tiny bit of yeast is used to make the dough. My default pizza recipe calls for around 150 mg of dry yeast per kg of flour. Give it a shot yourself the next time you make a yeast-based dough. Try to push the fermentation to at least 8 hours. The difference is incredible. You will have made bread with a much more fluffy and open crumb. The flavor of the dough is drastically improved. Your crust becomes crisper and features a better taste. This is because amylases have converted your starches into simpler sugars which brown better during baking. If you only learn one thing from this book, it is that slow fermentation is the key to making great bread.

For this reason, my default hydration is much lower than the hydration of other bakers. I prefer slower fermentation for my recipes. The sweet spot for my default flour is at around 70 % hydration. Again, this is a highly subjective value that works for my flour.

If you are just getting started with a new batch of flour, I recommend conducting the following test. This will help you to identify the sweet spot of your flour's hydration capabilities.

Make 5 bowls with each 100 g of flour. Add different slightly increasing water amounts to each of the bowls.

- 100 g of flour, 55 g of water
- 100 g of flour, 60 g of water
- 100 g of flour, 65 g of water
- 100 g of flour, 70 g of water
- 100 g of flour, 75 g of water

Proceed and mix the flour and water mixture until you see that there are no chunks of flour left. Wait 15 minutes and return to your dough. Carefully pull the dough apart with your hands. Your dough should be elastic, holding together very well. Stretch your dough until very thin. Then hold it against a light. You should be able to see through it. The flour-water mixture that breaks without seeing the windowpane is your no-go zone. Opt for a dough with less hydration than this value. You will know that your flour mix can go up to 65 % hydration, for instance. Use the leftovers of this experiment to feed your starter.

From an economic perspective, water is the cheapest component in your bread dough. When running a bakery, a higher hydrated dough will weigh more and have lower production costs. The profit will be higher. This comes at the price of increasing labor costs and more potential failures due to the enhanced difficulty.

Figure 7.2: The window pane test allows you to see if you developed your gluten well enough.

7.5 How much starter?

Most bakers use around 20 % sourdough starter based on the flour weight. I recommend going much lower, to around 5 % to 10 %.

By adjusting the amount of pre-ferment you can influence the time your dough requires in the bulk fermentation stage. The more starter you use, the faster this process is. The smaller the starter quantity, the slower. With a higher quantity of starter, you are introducing more microorganisms to your main dough. The higher this quantity, the faster the rate of fermentation in your dough is.

The other factor influencing the rate of fermentation is the temperature of your dough. The warmer the temperature, the faster the process; the colder, the slower the process.

While food is available, the microorganisms will reproduce and increase in quantity. The process is a self-limiting: it stops when there is no more food available. This can be compared to wine making where the yeast ultimately sporulates and dies as ethanol levels increase. The ethanol creates an environment that makes it impossible for other microorganisms to join the feast. The same thing happens with the acidity created by the bacteria. The high acidity slows the fermentation process and prevents new microorganisms from entering the system.

Initially, your starter's properties are carried over to the main dough. Then, as time progresses, the microorganisms adapt to the new environment. If your starter is very bacterial then your main dough's fermentation will also be. You end up with a dough that is not as fluffy as it could be. It will taste quite sour, too sour for most people.

If you were to use an extreme value of around 90 % starter based on your flour, there would be very little room for the microorganisms to adjust in the main dough. If you were to just use 1 %, your microorganisms can regrow into a desirable balance in the dough. Furthermore, you need to consider that a high value of starter means a high inoculation with already fermented flour. As mentioned earlier, enzymes break down the dough. This means the higher this value, the more broken-down fermented flour you have. A too-long fermentation always results in a very sticky dough that cannot be handled. The more starter you use, the faster you will get to this point. If you were to use a very little amount of starter, your flour might have naturally broken down before the fermentation has reached the desired stage. You can observe this when using a small quantity of around 1 % sourdough starter. The small amount of added microorganisms will not be able to reproduce fast enough before the protease has broken down your dough completely.

As explained earlier the key to making great bread is a slow but not too slow fermentation. Enzymes require time to break down your dough. Taking all this into consideration, I try to aim for a fermentation time of around 8 to 12 hours. This seems to be the sweet spot for most of the flours that I have worked with. To achieve this, I use around 5 % of sourdough starter in summer times (temperatures around 25 °C (77 °F) in the kitchen). In winter times I opt for around 10 % up to 20 % sourdough starter (kitchen temperature around 20 °C (68 °F)). This allows me to use a sourdough starter that's not in perfect condition. As explained earlier, your bread dough is essentially a gigantic starter. The low inoculation rate allows the starter to regrow inside your main dough into a desirable balance. Furthermore, the enzymes have enough time to break down the flour. This also allows me to skip the so-called autolysis step completely (more in the next chapter). This greatly simplifies the whole process.

7.6 Autolysis

Autolysis describes the process of just mixing flour and water and letting this sit for a period of around 30 minutes up to several hours. After this process is completed, the sourdough starter and salt are added to the dough.[2]

The overall time that flour and water are in contact is extended. Thus you get the beneficial enzymatic reactions that improve the taste and characteristics of the dough.

[2] I have tested adding the salt at the start and end of the autolysis process and could not notice a difference. Based on my current understanding, the importance of adding salt later seems to be a myth.

I do not recommend autolysis as it adds an unnecessary step to the process. Instead, I recommend the fermentolysis technique which will be covered in the next chapter of this book.

The effects of autolysis are very interesting. Try to mix just flour and water and let that sit for a day. During the day, check the consistency of your dough. Try and stretch the dough. If you dare, you can also taste the dough throughout the day. With each hour, your dough will become more extensible. It will be easier to stretch the dough. At the same time, your dough will start to taste sweeter and sweeter. The protease and amylase enzymes are doing their job. The same process is used when making oat milk. By letting the mixture sit for some time, enzymes work on the oats. The taste is perceived as sweeter and more appreciated. This process is further accelerated the more whole-grain your flour is. The hull contains more enzymes. The gluten network will ultimately tear, and your dough flattens out. For wheat sourdough, this is your worst enemy. When this happens, your dough will become leaky and release all that precious gas created during the fermentation. You need to find the right balance of your dough breaking down just enough and not too much.

When you use a high inoculation rate of around 20 % sourdough starter your fermentation can be very quick. At 25 °C it could be finished in as little as 5 hours. If you ferment longer, your dough becomes leaky. At the same time, in these 5 hours, the enzymes have not broken down the flour enough. This means the dough might not be as elastic as it should be. Furthermore, not enough sugars have been released and thus the flavor after baking is not good enough.[3] That's why bakers opt for autolysis. The autolysis starts the enzymatic reactions before the microorganism fermentation begins. This way after 2 hours of autolysis (an example) and 5 hours of fermentation the dough is in the perfect state before beginning proofing.

When you try to mix your salt and starter into the flour/water dough you will notice how cumbersome this is. It feels like you have to knead again from scratch one more time. You will spend more time mixing dough.

For that reason, I am strongly advocating utilizing the fermentolysis approach which greatly simplifies the mixing and kneading process.

7.7 Fermentolysis

The fermentolysis creates the same advantageous dough properties the autolysis creates without the headache of mixing your dough twice. You do this by extending the fermentation time of your dough. Rather than doing a 2-hour autolysis and 5-hour bulk fermentation you opt for an overall 7-hour fermentation period.

[3] I have not seen studies yet looking at enzymatic speeds depending on the temperature. But I assume the higher the temperature, the faster these reactions. This goes up until a point when the enzymes break down under heat.

To do this, you use less sourdough starter. A conventional recipe including the autolysis step might call for 20 % sourdough starter. Simply reduce this value to 5 % to 10 %. The other option could be to place the dough in a colder environment and thus reduce the speed at which your microorganisms replicate.

	Amount (%) for a starter	
°C / °F	**Recently fed**	**Starving**
30 / 86	5	2.5
25 / 77	10	5
20 / 68	15	10

Table 7.1: A table visualizing how much sourdough starter to use depending on temperature and the starter's activity level.

Based on my experience and my sourdough, my ideal bread always takes around 8 to 12 hours during bulk fermentation. Based on my availability throughout the day, I use a higher or lower starter quantity. If I wanted to achieve a completed fermentation in 8 hours, I would opt for a 10 % sourdough starter. If I wanted it to be ready in 12 hours, I would opt for less starter, around 5 %. Simply mix all the ingredients and your fermentation begins. The enzymes and microorganisms commence their work. On a very warm summer day, the mentioned quantities no longer work. With a 10 % starter, the same dough would be ready in 5 hours up to a point of no return. Another additional hour would cause the dough to break down too much. In this case, I would opt for 5 percent sourdough starter to slow the whole process down to reach the 8 to 12 hour window again. If it is very hot, I might use as little as 1 % sourdough starter.[4] You have to play with the timings on your own. Rather than relying on timing though, I will show you a much better and more precise approach by using a fermentation sample. This will be covered later in this chapter.

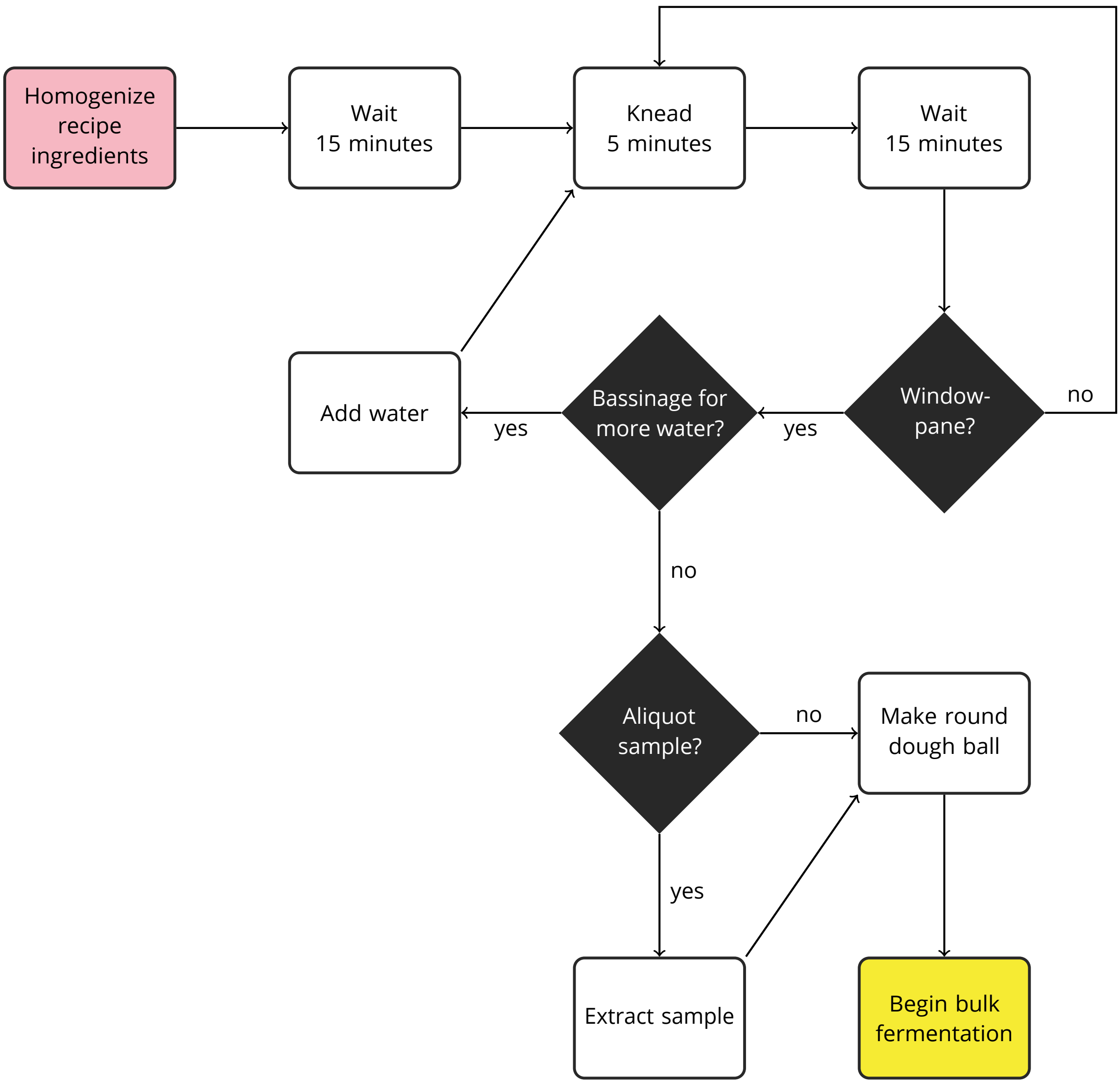
Even for yeasted doughs, I no longer use autolysis. I just reduce the amount of yeast that I am using. Opting for the fermentolysis will save you time and simplify your bread-making process. As mentioned in previous chapters, the secret to making great bread is a slow but not too slow fermentation.

7.8 Dough strength

Dough strength is a fancy way to describe the bread-kneading process. As you wait and knead, the gluten bonds in your dough become stronger. The dough becomes

[4]Please take these values with a grain of salt as they depend on your flour and your sourdough starter. These are values that you have to experiment with. After baking a couple of breads you will be able to read your dough much better.

more elastic and holds together better. This is the basis for trapping all the gases during the fermentation process. Without the gluten network, the gases would just diffuse out of your dough.



Flowchart 7.3: The gluten development process for a wheat-based dough.

It might sound odd, but the most important part of kneading is waiting. By waiting you are allowing your flour to soak up water. This way the gluten bonds of your dough form automatically and your dough becomes more elastic. So you could be kneading for 10 minutes initially just to be surprised that kneading 5 minutes and waiting 15 minutes has the same effect.

The gluten proteins glutenin and gliadin virtually instantly bond after being hydrated. Disulfide bonds enable the longer portions of glutenin to join with one another and form sturdy, extensible molecules. Glutenins add strength, whilst the more compact gliadin proteins allow the dough to flow like a fluid. Ultimately, the longer you wait, the more your gluten network transforms into a web-like structure. This is what traps the gases during the fermentation process [29].

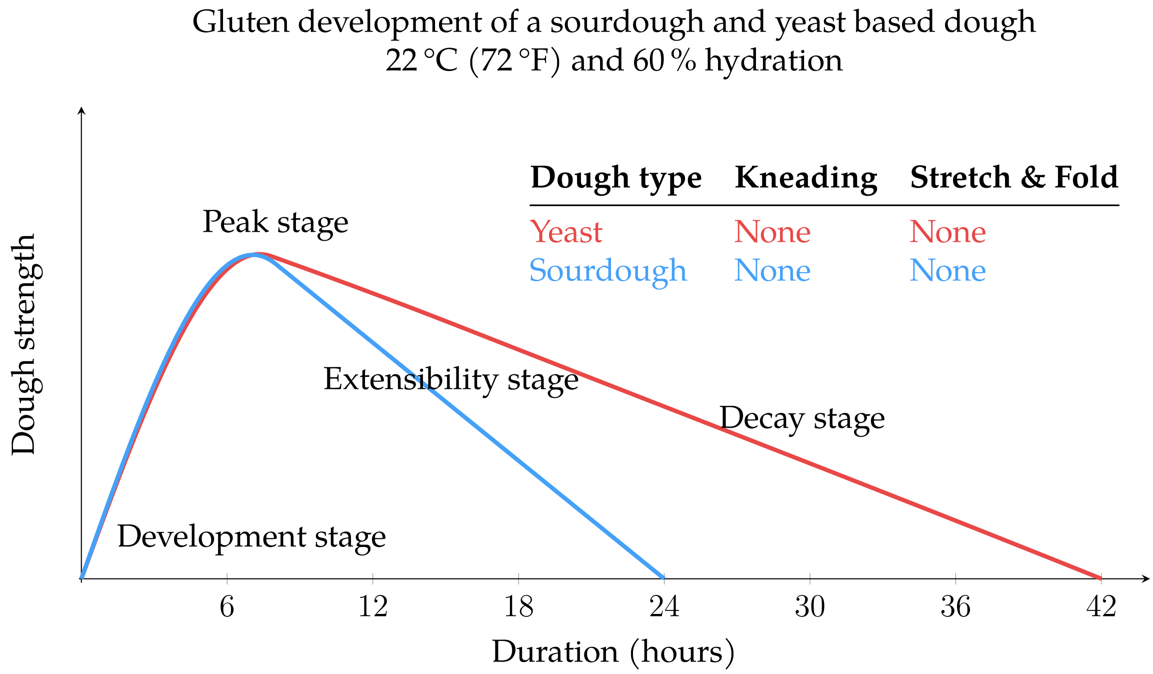


Figure 7.3: A schematic visualization of automatic gluten development. The doughs are not kneaded, just initially mixed. Note how dough strength deteriorates over time as enzymes break down the flour. The effect is accelerated for sourdough due to the bacteria's gluten proteolysis.

The soaking process has to be extended the more whole-wheat flour is used. The purpose of the wheat kernel's outer bran is to soak up water as fast as possible. The enzymes become activated and start the sprouting process. Because of this, less water is available for the gluten bonds to develop. Either wait a bit longer or proceed and use slightly more water for the dough.

This is the same principle that popular no-knead recipes follow. By making a less hydrated dough and waiting your gluten network automatically forms. You still have to mix and homogenize the ingredients. You wait a few minutes just to find your dough having developed incredible dough strength with no additional kneading.[5]

If you over-hydrate your dough at the beginning it becomes more difficult for the gluten chains to form. The molecules are not as close together in a wetter dough compared to a stiffer dough. It is harder for the molecules to align and form the web structure. For this reason, it is always easier to start with lower hydration and then increase the water quantity if needed. This is also commonly known as the *Bassinage method*. The gluten

[5]Give it a shot yourself. The automatic formation of gluten networks is an amazing phenomenon that still fascinates me every time I am making dough.

bonds have formed at the lower hydration and can then be made more extensible by adding water and kneading again. This is a great trick to make a more extensible dough with lower-gluten flour [49].

When machine kneading a dough, opt for the same technique shown in figure 7.3. Initially opt for a low speed. This helps the homogenization process. After waiting to allow the flour to soak up the water, proceed on a higher speed setting. A good sign of a well-developed gluten network is that your dough lets go of the container. This is because of the gluten's elasticity. The elasticity is higher than the desire of the dough to stick to the container.

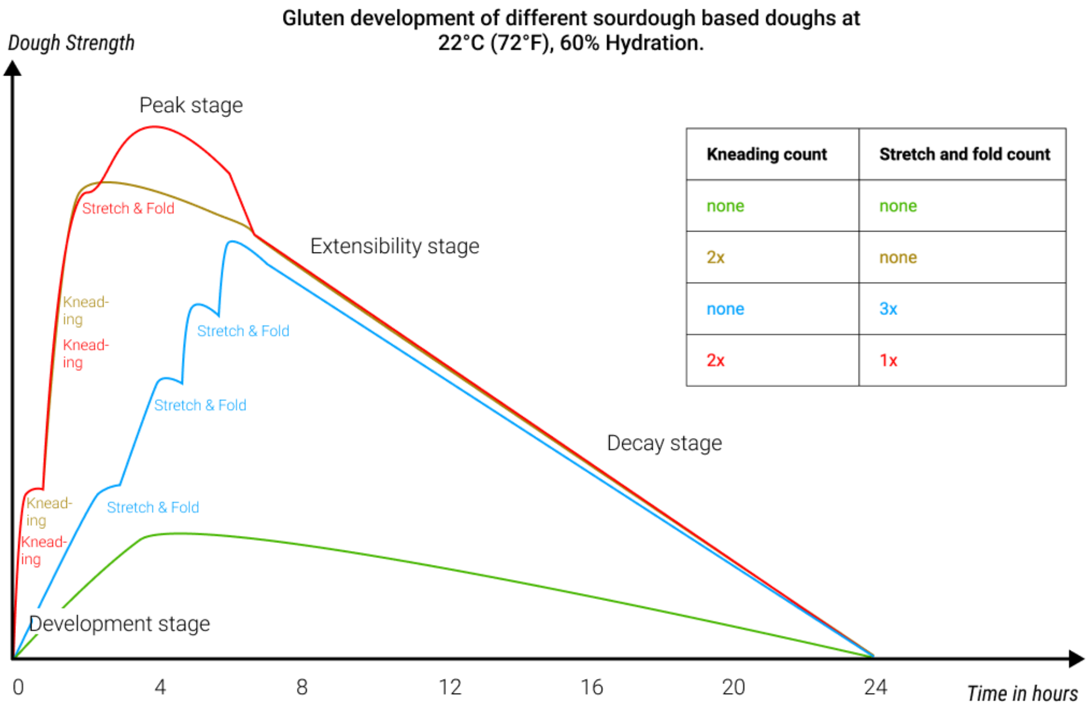


Figure 7.4: A schematic visualization of gluten development in sourdoughs with different kneading techniques. A combination of techniques can be utilized to achieve maximum dough strength.

Generally, the more dough strength you create, the less sticky your dough is going to feel. As the dough holds together, it will no longer stick to your hands as much. This is a common problem beginners face. Sticky dough is frequently the sign of a not well enough developed gluten network.

Kneading more is generally beneficial in almost all cases, as it results in a stronger gluten network. However, when making soft milk breads, you might prefer a more extensible dough from the start. In this scenario, excessive kneading could lead to a chewier final bread, which is not desirable if you aim for a fluffier texture. Achieving this fluffier dough can be accomplished by kneading less. While this is an exception, properly kneading your wheat-based doughs is generally advised.

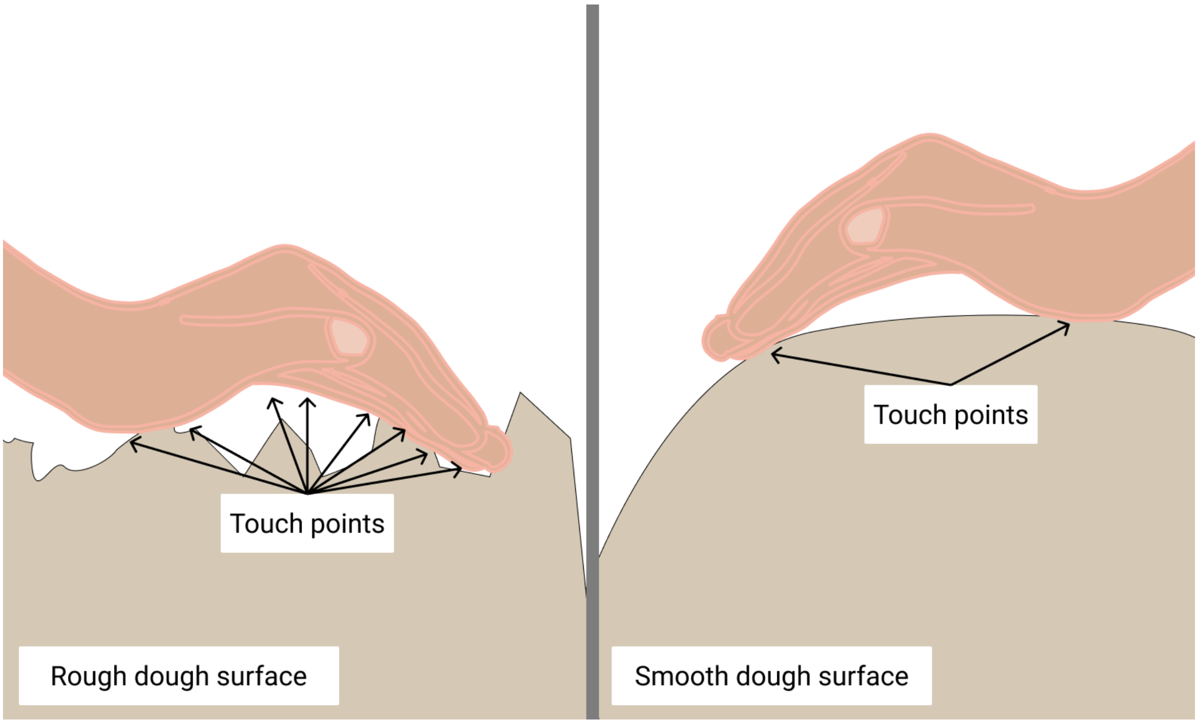


Figure 7.5: A schematic visualization of how a rough dough surface creates more touch points compared to a smooth dough surface. By touching the rough surface the dough will swell and get into contact with more areas of your hand.

When you use a stand mixer, you can run into the issue of kneading too much. This is almost impossible in practice though. Even after kneading for 30 minutes on medium speed, my doughs hardly ever were over-kneaded. The moment you knead too much, the color of the dough can begin to change. You mostly notice this, though, during baking. The resulting loaf looks very pale and white. This is because mixing dough causes oxidation, which is necessary for the development of gluten. However, if the dough is mixed too much, the compounds that contribute to the bread's flavor, aroma, and color may be destroyed, negatively affecting the quality of the bread [19].

The last step before beginning bulk fermentation is to create a smooth dough ball. By making sure your dough's surface is smooth, you will have fewer touch points when touching the dough. See figure 7.5 for a schematic visualization of how your hand touches a rugged and smooth dough. With the smooth surface, your dough is going to stick less on your hands. Applying later stretches and folds will be a lot easier. Without a smooth surface, the dough becomes almost unworkable. Folding the dough later becomes an impossible task. This is a frequent mistake I see many new bakers commit.

To make the dough's surface smooth, place your dough on a wooden board or on your kitchen's countertop. Drag the dough with your palm over the surface. A dough scraper could be used here for assistance. Drag the dough towards you while making

Figure 7.6: The transformation of a sticky dough blob to a dough with a smooth surface. The goal is to reduce surface touchpoints with your hands to make the dough less sticky when working it.

sure the top center of the dough stays in place. It can help to gently place your second hand on top of the dough so that the dough mass moves while retaining its orientation. Once the whole dough is too close to the edge of the container/countertop, gently move it back with two hands. By doing so, you are stretching the outer surrounding gluten layer. For this reason, it is important to not use any flour during this process. By using flour, you can no longer drag the dough over the surface and thus you can't stretch the gluten. Always imagine you are touching something utterly sticky. By doing so you will automatically try to touch the dough as little as possible. Keep repeating the process until you see that the dough has a nice smooth surface. The final dough should look like the dough shown in 7.6.

If your outer gluten layer tears, you have overstretched your dough. In that case, take a 10-minute break, leaving your dough on the kitchen countertop. This allows the gluten to re-bond and heal. Repeat the same process and the damaged rugged areas should disappear.

The same dough-rounding technique is used later during the pre-shaping process. After creating dough strength you have all the time you need to practice rounding. Round the dough as much as possible until it tears. Then wait the aforementioned 10 minutes and repeat. Later, you don't have any room for error. Your technique has to be on point. An over-pre-shaped dough can potentially not recover.

7.9 Bulk fermentation

After mixing the starter into your dough, the next stage of the process known as bulk fermentation begins. The term *bulk* is used because in bakeries, multiple loaves are fermented together in bulk. If you are a home baker, you might bulk ferment a single loaf. The bulk fermentation ends when you divide and pre-shape, or directly shape your final loaves or loaf.

The hardest part when making sourdough bread is controlling the fermentation process. Bulking long enough but not too long is the deciding factor for making great bread at home. Even with poor shaping and baking techniques, you'll be able to make excellent bread, solely by mastering the bulk fermentation process.

With a too-short bulk, your crumb will be perceived as gummy. Your crumb will feature large pockets of air commonly referred to as *craters*. A too-long fermentation results in the dough breaking down too much. The resulting dough will stick to your banneton and spread while baking into a pancake-like structure.

The key is to find the sweet spot between not too little and not too much bulk fermentation. I'd always recommend pushing the dough more toward a longer fermentation. The flavor of the resulting bread is better compared to a pale underfermented dough.

The worst thing you can do when fermenting sourdough is to rely on a recipe's timing suggestions. In 99 % of the cases, the timing will not work for you. The writer of the recipe probably has different flour and a different sourdough starter with different levels of activity. Furthermore, the temperature of the fermentation environment might be different. Just small changes in one parameter result in a completely different timing schedule. One or two hours' difference results in the dough not fermenting long enough, or turning it into a gigantic sticky fermented pancake. This is one of the reasons why the current baking industry prefers to make solely yeast-based doughs. By removing the bacteria from the fermentation, the whole process becomes a lot more predictable. The room for error (as shown in figure 7.3) is much larger. The doughs are perfect to be made in a machine.

Experienced bakers will tell you to go by the look and feel of the dough. While this works if you have made hundreds of loaves, this is not an option for an inexperienced baker. As you make more and more dough, you will be able to judge the dough's state by touching it.

My go-to method for beginners is to use an *Aliquot jar*. The aliquot is a sample that you extract from your dough. The sample is extracted after creating the initial dough strength. You monitor the aliquot's size increase to judge the level of fermentation of your main dough. As your dough ferments, so does the content of your aliquot jar. The moment your sample reached a certain size, your main dough is ready to be shaped and proofed. The size increase you should aim for depends on the flour you have at hand. A flour with a higher gluten content can be fermented for a longer

	Fermentation		
	Too short	**Too long**	**Perfect**
Crumb texture	Unbaked gummy areas towards the bottom of the bread.	Crumb can be perceived as gummy as most gluten broken down.	Crumb evenly baked. Crumb can be perceived as moist, but not gummy.
Alveoli	Overly large alveoli in the crumb "craters".	Many tiny alveoli equally distributed.	Alveoli evenly distributed, no "craters".
Taste	Pale neutral taste.	Strong acidic flavor profile. Acidity overweighs when tasting.	Balanced flavor profile, not too mild but also not too sour. Depending on starter vinegary or lactic notes.
Texture	Overall poor texture.	Good consistency, crumb is not as fluffy as it could be.	Great combination of textures.
Oven spring	Vertical oven spring, mostly due to water evaporating and inflating the dough.	Very flat pancake like structure after baking.	Great vertical oven spring. Dough grows more upwards rather than sideways.

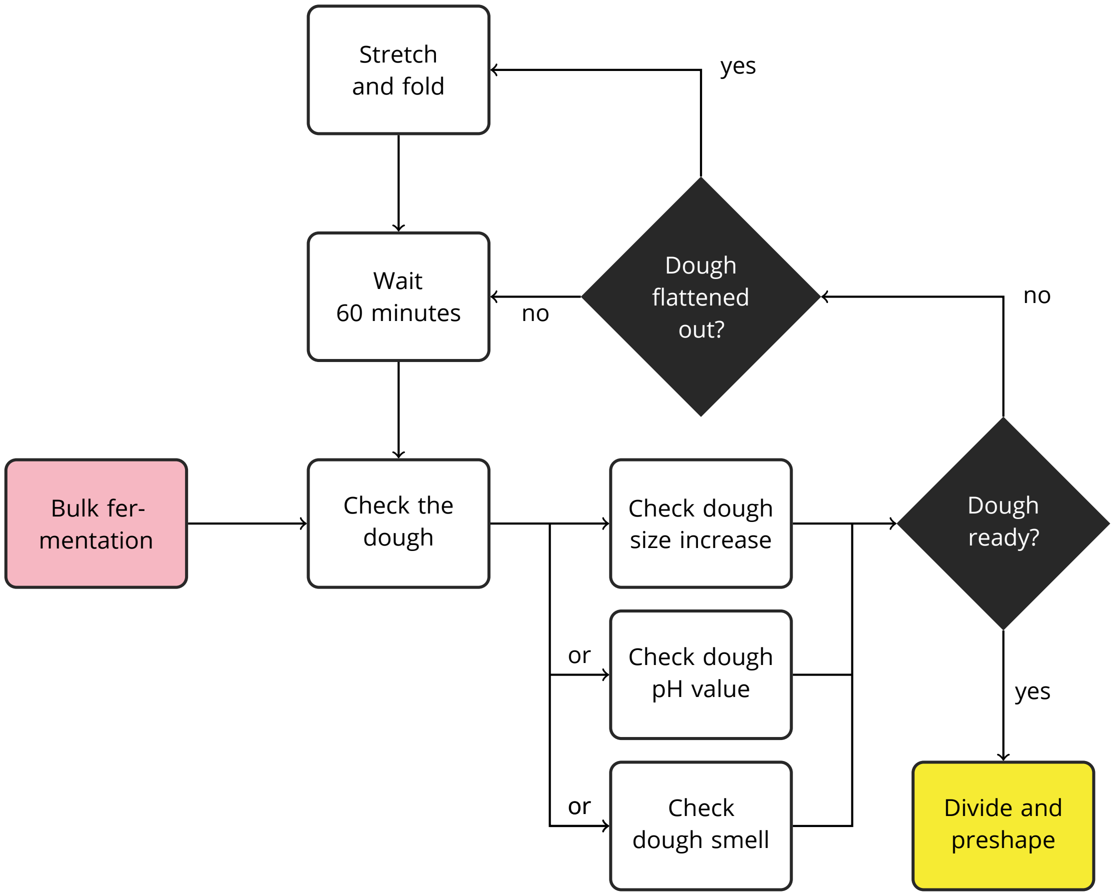
Table 7.2: The different stages of sourdough fermentation and the effects on crumb, alveoli, texture, and overall taste.

period. Generally, around 80 % of your wheat flour's protein is gluten. Check your flour's packaging to see the protein percentage. The actual size increase value is highly variable depending on your flour composition. I recommend beginning with a size increase of 25 % and testing up to 100 % with subsequent bakes. Then identify a value that you are happy with.

Flour protein content	**Relative aliquot size increase**
8–10%	25%
10–12%	50%
12–15%	100%
> 15%	> 100%

Table 7.3: Reference values for how much size increase to aim for with an aliquot jar depending on the dough's protein content.

The beauty of the aliquot is that no matter the surrounding temperature, you will always know when your dough is ready. While the dough might be ready in 8 hours



Flowchart 7.4: During the bulk fermentation, multiple doughs are fermented together in bulk. A challenging aspect of homemade sourdough bread is to determine when this stage of fermentation is completed. This chart shows multiple available options to check on the bulk fermentation progress.

in summer, it could easily be 12 hours in winter. You will always ferment your dough exactly on point.

While the aliquot sample has enabled me to consistently bake great loaves, there are limitations to consider. It's crucial to use a cylindrical-shaped container to properly judge the dough's size increase. Furthermore, it is essential to use room-temperature water when making your dough. If the water is hotter, your aliquot, due to its smaller size, will cool down faster. The aliquot will ferment more slowly than your dough. Similarly, when you use too cold water, your sample will heat up faster than the large dough mass. In that case, your aliquot is ahead of your main dough. You would probably stop the fermentation too early. Make sure to keep the dough and aliquot close together. Some people even place the aliquot in the same container. This makes sure that both are in the same environment temperature. The aliquot is also less reliable if your ambient temperature changes a lot during the day. In that case, your aliquot

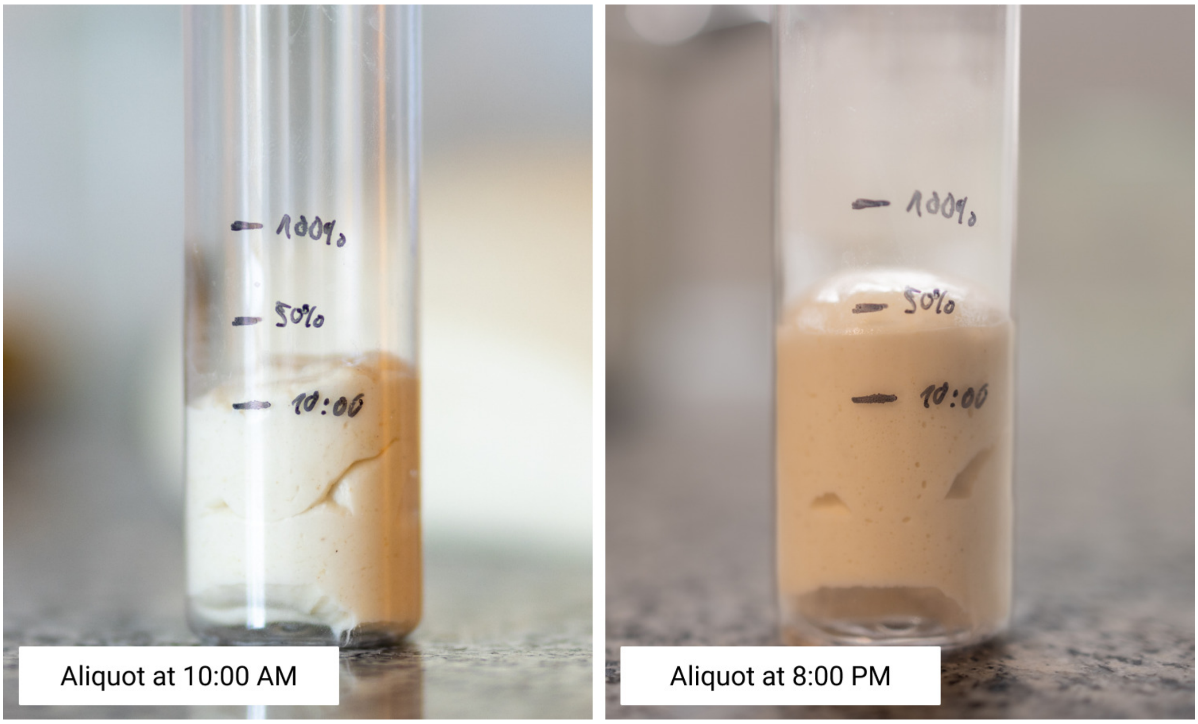


Figure 7.7: An aliquot jar to monitor the dough's fermentation progress. It took 10 hours for the dough to reach a 50 % size increase.

will adapt faster than your main dough. The readings will always be slightly off. If you are making a large chunk of dough with more than 10 kg of flour, the jar is also less reliable. The biochemical reactions happening inside your dough will heat it. The fermentation itself is exothermic which means that it produces heat.

Another more expensive option is to use a pH meter to monitor your dough's fermentation state. As the lactic and acetic acid bacteria ferment, more acidity is piled up inside your dough. The acidity value (pH) can be measured using such a meter. The more acidity, the lower the pH value of your dough. The pH scale is logarithmic, meaning that each digit change will have a 10x increase in acidity. A sourdough dough might begin fermenting at pH 6.0, then shortly before baking has roughly pH 4.0. This means that the dough itself is 10x times 10x (= 100x) sourer than at the beginning. By using the meter, you can always judge the state of your dough's acidification and then act accordingly.

To use the pH meter successfully, you need to find pH values that work for your dough. Depending on your starter, water, and flour composition, the pH values to look out for are different. A stronger flour with more gluten can be fermented for a longer period. To find out the pH values for your bread I recommend taking several measurements while making your dough.

1. Measure the pH value of your sourdough starter before using it

2. Check the pH after mixing all the ingredients
3. Check the pH before dividing and pre-shaping
4. Check the pH before shaping
5. Check the pH of your dough before and after proofing
6. Check the pH of your bread after baking

If the bread you made turned out successfully with your values, you can use them as a reference for your next batch. If the bread didn't turn out the way you like, either shorten the fermentation or extend it a little bit.

Step	**pH Value**
Starter ready	4.20
Mixing	6.00
Dividing/preshaping	4.10
Shaping	4.05
Before proofing	4.03
After proofing	3.80
After baking	3.90

Table 7.4: Example pH values for the different breakpoints of my own sourdough process.

The beauty of this method is its reliability. Once you have found out your good working values, you can reproduce the same level of fermentation with each subsequent dough. This is especially handy for large-scale bakeries that want to achieve consistency in each bread.

While this method is very reliable, there are also certain limitations to consider.

First of all the pH values that work for me likely won't work for you. Depending on your own starter's composition of lactic and acetic acid bacteria, your pH values will be different. You can use the values shown in Table 7.4 as rough ballpark figures. Regardless, you need to find values that work for your setup.

Another limitation is the price. You will need to purchase a high-tech pH meter, ideally, a meter featuring a spearhead.[6] This way you can directly poke the meter deep into the dough. At the same time, automated temperature adjustments are a feature to look out for. Depending on the temperature, the pH value varies. There are tables you can use to do the adjustment calculations. More expensive meters have this feature built in. The pH meter loses accuracy over time. For this reason, you need to frequently

[6] Not every pH meter is suitable for measuring dough. Please refer to the manual to make sure it is certified for measuring the pH of liquid and semi-solid media. To receive accurate pH readings further ensure that your pH meter is properly calibrated.

calibrate it. The process is cumbersome and takes time. Lastly, you need to carefully rinse the pH meter before using it in your dough. The liquid surrounding the head of your pH meter is not food-safe and thus should not be eaten. I rinse the meter for at least one minute before using it to measure my dough's fermentation stage.

The last method to judge the state of bulk fermentation is to read the signs of your dough. The more bread you have made, the more accustomed you will become to this process. Look out for the dough's size increase. This can sometimes be a challenge when your dough is inside a container. You can help yourself by marking your container. Some bakers even use a transparent rectangular bulk container. You can use a pen to mark the initial starting point. From there on you can nicely observe the size increase. Similar to the mentioned aliquot sample, look out for a size increase that works for your sourdough composition.

Figure 7.8: A dough in a good state to finish bulk fermentation. Notice the tiny bubbles on the dough's surface. They are a sign that the dough is inflated well enough.

Look out for bubbles on the surface of your dough. They are a good sign that your dough is inflated with gas. The further you push the bulk fermentation the more bubbles will appear. If you overdo this stage, the dough becomes leaky, and the bubbles will disappear again.

Take note of the dough's smell. It should match the same smell of a ripe starter shortly before collapsing. As mentioned before, your dough is nothing but a gigantic starter.

You can also proceed and taste your dough. It will taste like pickled food. Depending on the acidity you can judge how far the dough is in the fermentation process. The final bread will taste less sour. That's because a lot of acidity evaporates during baking.[7]

When touching the dough, it should feel tacky on your hands. The dough should also be less sticky compared to earlier stages. If the dough is overly sticky, you have pushed the fermentation too far.

If you pushed the bulk fermentation too far, you won't be able to bake a freestanding loaf with the dough anymore. But don't worry. You can move your dough into a loaf pan, or use parts of the dough as the starter for your next dough. When using a loaf pan, make sure it's properly greased. You might have to use a spatula to transfer your dough. Allow the dough to proof for at least 30 minutes in the loaf pan before baking it. This makes sure that large cavities induced by the transfer are evened out. You could push the proofing stage to 24 hours or even 72 hours. The resulting bread would feature an excellent, very tangy taste.

7.10 Stretch and folds

In this section, you will learn all you need to know about stretching and folding. You will learn when to stretch and fold and how to use this technique to your advantage.

Stretching and folding is a set of techniques used by bakers during the bulk fermentation stage. The process involves stretching the dough and then folding the dough onto itself. Some recipes call for a single stretch and fold, others for multiple.

The primary goal of this technique is to provide additional dough strength to your dough. As shown in figure 7.4 there are multiple ways to create dough strength.[8] If you do not knead as much at the start, you can reach the same level of dough strength by applying stretch and folds later. The more stretch and folds you do, the more dough strength you add to your dough. The result will be a more aesthetic loaf that has increased vertical oven spring.

Sometimes, if the dough is very extensible and features very high hydration, stretching and folding is essential. Without it, the dough itself would have too little dough strength and not spring in the oven at all.

Another benefit of stretch and folds are their homogenization properties. By folding the dough you are redistributing areas that are fermenting faster than other areas. The

[7] More on this topic later. Just by baking longer and/or shorter, you can control the tang of your final baked bread. The longer you bake, the less sour the final loaf. The shorter, the more acidity is still inside the bread. The resulting loaf will be sourer.

[8] In fact I have seen many no-knead recipes calling for no initial kneading, but then applying stretch and folds during the bulk fermentation. The time required to do all the folds probably matches the initial kneading time required.

Figure 7.9: A dough where two sticky sides are being glued together using a stretch and fold. This process creates excellent dough strength.

heat in your dough is not the same in all areas. The fermentation itself produces heat. For that reason, some of the areas in your dough will ferment a little faster than others. This means that some areas hold more gas and more acidity than others. Applying a stretch and fold will redistribute heat, gas, and acidity. Some bakers also refer to this process as crumb building. Careful folds ensure that your final dough's crumb is not overly wild featuring large cavities. If you notice overly large cavities in your final dough's crumb, then you might be able to fix that by applying more stretch and folds.[9] Please refer to Section 12.4 "Debugging your crumb structure" for more information on reading your crumb.

The reason for the technique's popularity lies in its efficiency. By stretching the dough outwards, you increase your dough's surface area. You then fold the dough over, essentially gluing large areas of the dough together. Imagine a piece of paper on which you place the glue. Then you fold the paper. Large areas of the paper now stick together. Repeat the same process with more glue until you have created multiple layers of paper and glue. This is the same thing that happens to your dough. With only very few movements you have applied glue to your dough.

[9] In many cases these cavities can also happen when a dough does not ferment enough. The crumb is commonly called Fool's Crumb. Refer to the later Debugging Crumb Structures chapter of this book to learn more about it.

Figure 7.10: An overview of the steps involved to perform stretch and folds for wheat-based doughs.

To apply a stretch and fold first wet your hands with cold water. Watered hands work wonders in reducing the dough's tendency to stick to your hands. Proceed and carefully loosen the dough from the edges of your bulk container. Do this by carefully placing your hand at the edge of the dough and pushing your hand downwards on the container's walls. Once you have reached the bottom, drag the dough a little bit inwards. The dough should stay in place and not move back to the edge of your container. Try to be as swift as possible with this motion. The slower you are, the more dough will stick to your hands. Repeat the same process once all around your dough until the dough is free of your container's edges. Wet your hands one more time and then carefully lift one side of the dough with two hands placed in the center upwards. Make a fold in the center of the dough. The upper smooth side needs to be placed on the bottom of the container. By doing so, you will be gluing together the two sticky bottom sides. The top smooth side should not be sticky in your hands, while the bottom rough surface should tend to stick to your hands. Rotate the container and repeat the same thing from the other side. Rotate the container 90° and then repeat the process once again. Rotate the container another 180° in the same direction and repeat the fold one last time. By doing so you have applied 4 folds in total. Your dough should now stay in place and resist flowing outwards.[10]

In theory, there is no limit to how often you can stretch and fold. You could apply one every 15 minutes. If your dough has enough dough strength already, applying additional folds is just a waste of time.[11] If you apply a large number of consecutive folds, the outer layer of gluten will tear. In that case, you just have to wait for at least

[10]Please also refer to [55] for a video showing you how to best perform the technique.
[11]You could do it just to better understand how the dough feels in your hands at different fermentation stages.

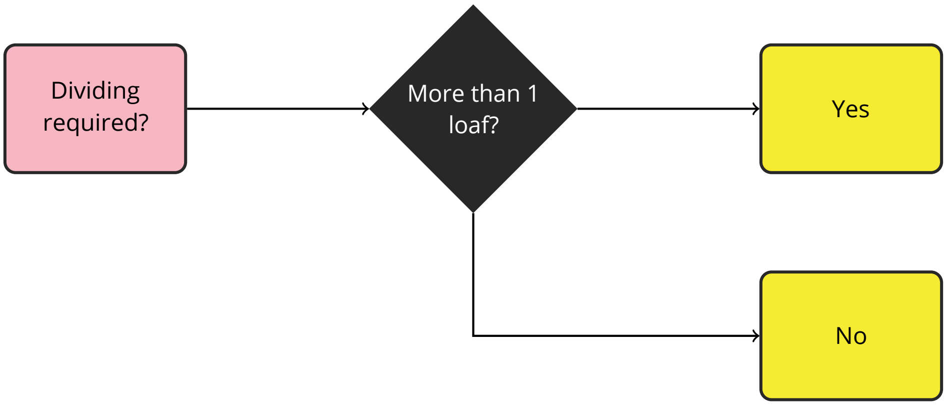
5–10 minutes until the gluten bonds heal and you can try again. When the gluten does not heal anymore, chances are you have pushed the fermentation for too long. Likely most of the gluten has broken down and you are already in the decay stage shown in figure 7.4.

Figure 7.11: A dough during bulk fermentation that has flattened out. To improve its dough strength, a stretch and fold should be applied.

Now, the reasonable amount of stretch and folds you should do greatly depends on how much you kneaded initially and how extensible your dough is. A good recommendation is to observe your dough in your bulk container. Once you see that the dough flattens out quite a lot and spreads towards the edges of your bulk container, you can proceed and apply a stretch and fold. For 95 % of the doughs that I am making, this is hardly more than once. I like to make overnight doughs and in that case, I typically apply one stretch and fold directly after waking up. Then the bulk fermentation might take another 2 hours before I proceed with dividing and pre-shaping or directly shaping.

7.11 Optional: Dividing and Preshaping

Dividing and pre-shaping is an optional step that is done once your sourdough finishes with the bulk fermentation stage. The step is required if you are making multiple loaves in one batch. It is optional if you are making a single loaf.



Flowchart 7.5: Dividing is only required when you are making multiple loaves in a single dough batch.

The goal of dividing your dough into smaller pieces is to portion your dough accordingly. This way you'll have multiple pieces of bread which all weigh the same. For this reason, a scale is commonly used to weigh the pieces of dough. If one piece of dough weighs too little you can simply cut a bit more from your dough blob to increase its weight.

When cutting the dough, try to be as concise as possible with your movements. You don't want to unnecessarily damage your dough too much. Quick movements with a knife or dough scraper help to prevent the dough from sticking too much to your tools.

I sometimes like to draw small lines with the dough scraper's edge on the large dough mass before cutting it into smaller pieces. This helps me to better plan where I want to do my incisions. When I plan to make 8 loaves I try to use the lines to divide the dough into 8 equally sized portions before cutting. If this is not precise enough, you can use the aforementioned scale.

Now that you have cut your dough, the resulting chunks are not in an equal shape. This is problematic for the next stage when you are shaping your dough. The resulting loaves wouldn't look nice and even. You would probably end up with areas that tear the moment you are shaping your dough. You wouldn't start the whole proofing process on a good foundation. For that reason, you need to pre-shape your dough.

Pre-shaping is done for several reasons:

- You divided your dough and require pre-shaping

Figure 7.12: The steps of dividing and preshaping your dough.

- Your dough lacks dough strength. Pre-shaping will add more strength
- You want to even out the final loaf's crumb structure. By pre-shaping, the resulting crumb will look more even.

If you are making a single loaf from one dough batch the step is not required. In that case, you can directly proceed with shaping, skipping this step.

The pre-shaping technique is the same as the process figure 7.6. Whereas earlier you could tear the dough's surface this could now result in a catastrophe. For this reason, I recommend practicing this step for as long as you need after kneading. The gluten network might be so extensible and degraded at this point that there is hardly any room for error. The dough wouldn't come together again. The only way to save such dough is to use a loaf pan.

Pre-shape the dough as much as is needed to round up the top surface area. Try to touch the dough as little as possible to reduce its ability to stick to your hands. Drag the dough in the direction where you see a rough surface area. In case you have too little space to drag the dough because it might fall from the edge of your counter, simply lift it with a swift movement and place it in a better position for pre-shaping. Please refer to figure 7.13 for a visualization showing the pre-shaping direction.

Try to set yourself a limit of movements to finish pre-shaping a dough. Then you will be more conscious about each movement you are performing. At the start you can try 5 movements, iteratively reducing this to 3. The only reason for exceeding these numbers could be if you on purpose want to even out the crumb structure of your final loaves further.

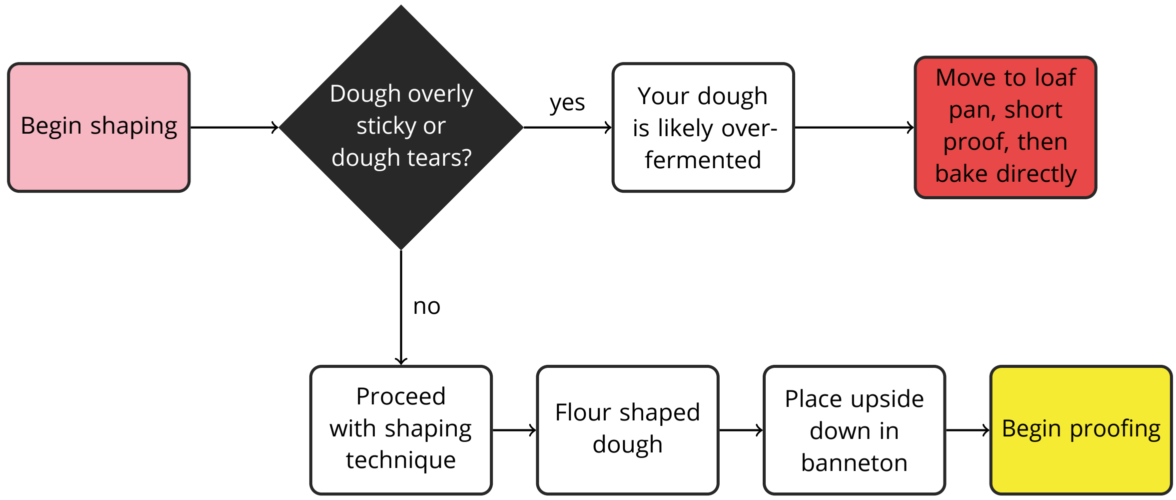
Figure 7.13: Drag the dough in the direction of the rough surface area. This way you minimize the movements required to complete the step.

Figure 7.14: Baguette doughs resting after preshaping.

Once you finished pre-shaping allow the dough balls to rest on your counter for at least 10–15 minutes. Do not cover the pre-shaped balls. By drying out the surface, the following shaping step will be easier. The dried-out surface will not stick to your hands as much. As you tightened the dough's gluten you will need to allow it to relax. Without a resting period, you wouldn't be able to shape your dough into, for instance, a baguette-like structure. The dough would resist each movement always springing back into the previous shape. You might have noticed this before, when making pizza dough. If you don't wait long enough after balling the pizzas, it's impossible to stretch the pizza. By waiting a few more minutes, stretching becomes a lot easier. The dough will not resist being transformed into the final shape that you like.

The aforementioned 10–15 minutes bench rest time depends on how strongly you pre-shaped your dough. The more you pre-shape the longer you need to wait. If your dough resists a lot during shaping, extend this period up to 30 minutes. If you wait too long, your dough's surface area can become too dry, resulting in the dough tearing during shaping. As always, please take these timings with a grain of salt and experiment in your environment.

7.12 Shaping



Flowchart 7.6: A schematic visualization of the shaping process including checks for an overfermented dough.

Shaping will give your dough the final shape before baking. After completing shaping, your dough proceeds to the proofing stage and will then be scored and ultimately baked.

There are countless shaping techniques. The technique to choose depends on the type of bread you want to make. Some techniques are gentler on the dough, making sure that the dough does not degas. Other techniques are faster but degas the dough a little more. The tighter you shape, the more evened out your final dough's crumb structure will look. At the same time, a tighter shaping-technique will improve your dough's strength. More strength will ultimately result in more vertical oven spring.

The following instructions assume that you want to make a batard-style bread featuring an oblong shape. Learning this technique will provide you with a solid knowledge foundation that can easily be extended to make bread rolls or baguettes.

Mastering the challenging shaping technique will likely take you multiple attempts. You only have a single attempt per dough, though. If you make a mistake, the final bread is likely not going to turn out as good as it could. If this technique causes you a headache, I recommend making a larger batch of dough and dividing and preshaping it into smaller portions. Instead of making a large batard, practice making miniature batard bread rolls.

7.12.1 Apply flour to the dough's surface.

Figure 7.15: A dough that has flour applied to its surface. This is the first step of the shaping process.

If you are only making 1 loaf out of your dough, apply flour generously to the top layer of your dough. Rub the flour onto your dough with your hands. Flip over your container. Wait a little bit to allow the dough to release itself from the container. Proceed with step 3.

If you divided and pre-shaped, apply flour generously to the dough's top layer as well. With gentle hands spread the flour evenly across the dough's surface. See figure 7.15 for a visual representation of how your dough should look after coating the surface.

7.12.2 Flip the dough over

With gentle hands, carefully remove the dough from the surface. If you possess a dough scraper, carefully tuck it under the dough with rapid movements. Flip the dough over, making sure that the floured areas are in contact with your hands. The

Figure 7.16: A flipped-over dough. Note how the sticky side is facing you while the floured side is facing the countertop. The sticky side is used as glue to hold the dough together.

non-floured bottom area that was stuck to the counter is a no-touch zone. Try to avoid touching it as it is rough and thus will stick to your hands.

Gently proceed and place the dough with the previously top-facing side on your counter. The floured area is now on the surface, whereas the sticky side is facing you.

7.12.3 Make the dough rectangular

You should be facing the sticky side of your dough now. Note how the dough is currently round and not rectangular. The circular shape will not be ideal when shaping the oblong batard.

For this reason, proceed and stretch the dough a little bit until it has a more rectangular shape. While stretching, make sure to touch the sticky side as little as possible. Place your hands on the bottom floured side and the edge of the sticky side. With gentle hands, stretch the dough until the shape in front of you looks rectangular. Refer to figure 7.17 and compare your dough with the shown dough.

7.12.4 Fold the dough together

Now that you have created the rectangular shape, your dough is ready to be folded together. This only works because the side facing you is sticky. Because of the dough's

Figure 7.17: A flipped-over dough. Note how the sticky side is facing you while the floured side is facing the countertop.

stickiness, we can effectively glue it together, creating a very strong bond.

You can practice this step with a piece of rectangular paper. Once you mastered folding on paper you can easily apply this to your real-life dough.

Make sure the batard is placed in front of you. Take the side that faces you and fold it into the middle of the dough. Carefully tuck it down so that it glues together with the sticky side.

Take the other side and fold it over the side you just folded. Stretch the dough as much as possible towards you. Tuck it down on the edge, creating your first glue layer.

Rotate the dough so that it is aligned lengthwise in front of you. Rotate the dough inwards so that the seam side now faces you.

Start to roll the dough inwards beginning at the top of the dough. Keep rolling the dough inwards until you have created a dough roll.

Refer to figure 7.18 for a full visual representation of the process.

If your dough does not hold its shape, chances are you have pushed the fermentation too far. Most of the gluten has been degraded and the dough won't be able to hold its shape. In this case, the best option is to use a loaf pan to bake your bread. The final bread will taste amazing but not offer the same texture a freestanding bread would offer. Please refer to Section 12.4 for more details on how to properly read your dough's crumb structure.

Figure 7.18: The process of folding a batard. Note how the rectangle is first glued together and then rolled inwards to create a dough roll. Ultimately the edges are sealed to create a more uniform dough.

7.12.5 Sealing the edges

Your dough has finished shaping now. Sealing the edges is an optional step. I like to do it because, in my opinion, the final baked bread will look a little bit nicer without any rough edges.

Gently pull together the swirl-like-looking edges of your dough with two fingers. Rotate the dough and then repeat the same process from the other side as well.

7.12.6 Prepare for proofing

You should have a beautifully shaped dough in front of you now. The proofing stage is about to start. To simplify later scoring and to make sure your dough won't stick to your banneton, apply another flour rub to the dough's surface. This will dry out the surface and reduce the dough's tendency to stick to everything.

For the coating, I recommend using the same flour you used to make your dough. Rice flour is only recommended if you want to apply artistic scoring patterns later. It is

Figure 7.19: The shaped dough is ready for proofing in the banneton. Note how the seam side is now facing you. The floured previous top side is facing downwards.

better to use more flour than too little flour. Excess flour can be brushed off later.

Once your dough has been coated, it is ready to be placed on your banneton. If you do not have a banneton, you can use a bowl with a kitchen towel inside.

The currently top-facing floured surface will be downwards-facing in your banneton. By doing so the banneton can be flipped over before baking, releasing the dough.[12]

Proceed and lift the dough with 2 hands from the counter. Gently rotate it once and then place the dough in your banneton for proofing.[13] If you did everything right, then your dough should look somewhat similar to the dough shown in figure 7.19. As the last step of shaping, place a kitchen towel over your banneton or bowl and begin proofing.

[12]The same applies when making other doughs such as baguette doughs. The floured surface will always be downwards facing. The dough is then flipped over once for baking.

[13]The seam side should now be facing you. Some bakers like to seal the seam a little more. I did not notice that this improves the dough's strength. As far as I can tell, this only improves the visual appearance of the bottom side of the final loaf.

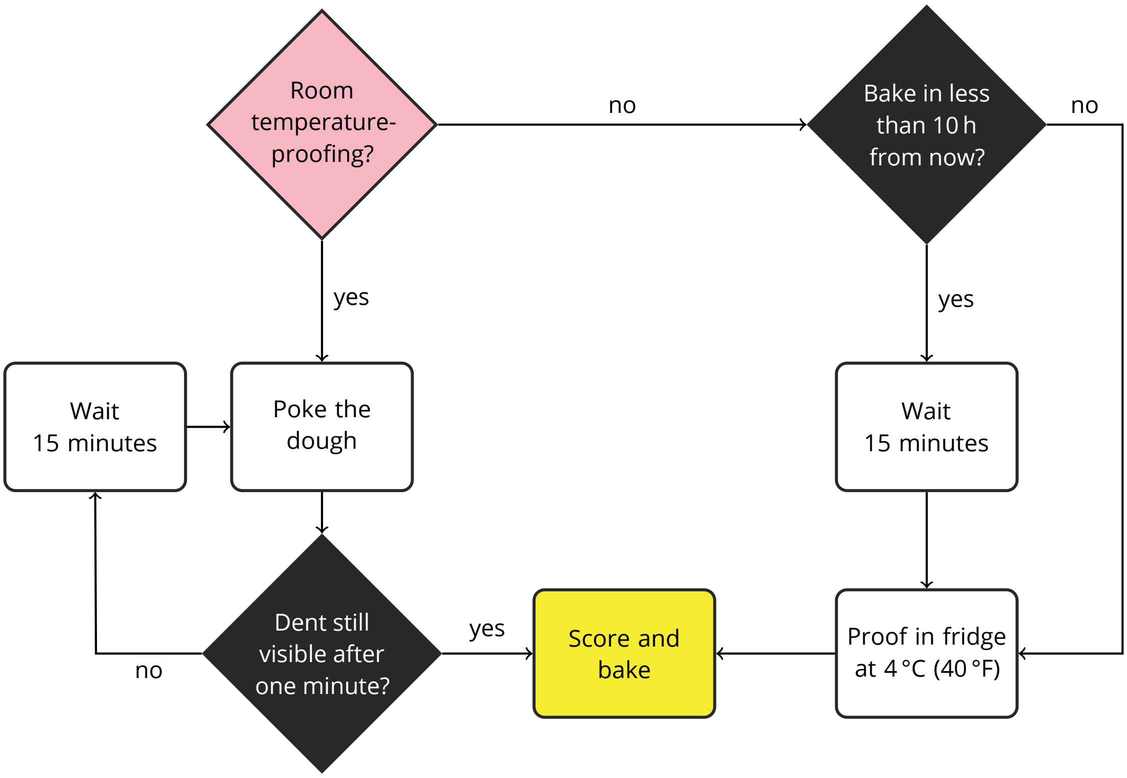
7.13 Proofing

In bread baking, proofing refers to the final rise of dough before baking, after it has been shaped into a loaf. The chemical reactions and processes that occur during bulk fermentation and proofing are the same.

By shaping your dough, it has lost some of the air previously generated throughout the bulk fermentation. The goal of proofing is to inflate the dough again. A dough without proofing wouldn't offer the same texture as a properly proofed dough. The proofed dough features a very fluffy and soft crumb.

There are two proofing techniques. One strategy is to proof the dough at room temperature whereas the other proofs the dough in the fridge. Fridge-proofing is also commonly known as retarding.

Some bakers claim that cold-proofing improves the final flavor of the bread. In all the loaves that I retarded I could not tell a difference in terms of flavor for cold-proofed doughs. The microorganisms work at a slower rate at colder temperatures. But I doubt that they alter their biochemical processes. More research is needed on the topic of retarding and flavor development.



Flowchart 7.7: A schematic overview of the different steps of the sourdough proofing process. The proofing technique to choose depends on your availability and schedule.

To me, the sole purpose of cold-proofing is its ability to allow you to better manage the timing of the whole process. Assuming you finished shaping your dough at 10 pm, chances are you wouldn't want to wait for another 2 hours to proof the dough and then another 1 hour to bake it. In this case, you can move your dough directly to the fridge after shaping. Your dough will be proofing overnight in the fridge. Then it can be baked at any time the following day (there are a few exceptions; more on that later). This is especially handy for large-scale bakeries that use fridge-proofing extensively. Some of the doughs are proofed a day before and placed in the fridge. Early in the morning, they can be baked directly out of the fridge. Within 2 hours they will be ready to sell the first bread to morning customers. If throughout the day more bread is needed, they simply take some proofed dough out of the fridge and bake it. The time frame in which you can bake retarded dough is big. It can be as little as 6 hours later up to 24 hours later.

Assuming you made an overnight dough and your dough is ready in the morning, the situation might be different. You potentially want to bake the dough directly for breakfast, or at lunchtime. In this case, you wouldn't want to proof the dough for another 6 hours in the fridge. Room temperature-proofing is your technique of choice.

To summarize, choose the technique that works for you depending on your schedule and availability.

7.13.1 Room temperature-proofing

The easiest and most reliable way to proof your dough is to proof the dough at room temperature. It is my method of choice if my schedule allows it. This method works great if you make an overnight dough and then proof it the next morning.

The time it takes to proof your dough can be anything between 30 minutes and 3 hours. Rather than relying on timing, most bakers use the finger poke test.

Flour your thumb and gently press around 0.5cm up to 1cm deep into the dough. Try this directly after shaping. You will notice that the created dent will recover quickly. It will be gone again after 1 minute.

As you proceed with proofing, your dough will fill up with more gas. At the same time, the dough will become more extensible. Once it starts to reach the right amount of fluffiness and extensibility, the dent will disappear more slowly. Once the dough is ready for scoring and baking the dent should still be visible after 1 minute of waiting.

I recommend performing the finger poke test once every 15 minutes throughout the proofing stage. Realistically, based on my experience, proofing takes at least one hour and can sometimes take up to 3 hours. Even at warmer temperatures proofing has

Figure 7.20: The finger poke test is a very reliable method to check if your dough has been properly proofed. If the induced dent is still visible one minute later, your dough can be baked.

never been faster than an hour for me. As always please take my timings with a grain of salt and experiment on your own.

Once I see that the dough is getting close to perfect proofing, I proceed and preheat my oven. This way I don't overproof the dough. You would notice an over-proofed dough when the dough suddenly becomes very sticky. At the same time, the dough is likely to collapse during baking and will not spring back. Generally, it is better to end proofing too early rather than too late.

7.13.2 Cold-proofing (retarding)

The second proofing option is to place your dough inside the fridge for proofing. This option is great if you do not want to bake the dough within the next 3 hours.

The dough will initially proof at the same rate as the room temperature dough. As the dough cools down the rate of fermentation slows. Ultimately at below 4 °C (40 F) the fermentation comes to a halt.[14] The dough can rest in the fridge for up to 24 hours. In some experiments, the dough was still good even 48 hours later. Interestingly, there is

[14]The actual temperature depends on the bacteria and yeast you cultivated in your sourdough starter.

a limit to fridge proofing. I can only explain this with continuous fermentation activity at low temperatures.

The hard part is to judge when the dough is finished proofing in your fridge. The previously mentioned finger poke test does not work on cold dough. Low temperatures change the dough's elasticity. The dent from the poke test will never recover.

For this reason, finding the best fridge-proofing time is best done with an iterative approach. Begin with 8 hours on your first dough, 10 hours on the second, 12 hours on the third, and so on up to 24 hours. As the temperature in your fridge is typically constant, you have an environment in which you can rely on timings. Find the ideal proofing time that works for you.

One additional consideration is the dough's core temperature before placing it inside the fridge. The warmer your dough is initially the longer it takes for the dough to cool down. This is an additional variable to take into consideration when choosing the retarding time. In summer times when my kitchen is hot, I choose a shorter fridge-proofing time compared to winter times when the dough is colder.

A reliable way to ensure consistent proofing is to opt for using a pH meter. By checking the amount of piled-up acidity you can ensure each of your doughs has the right amount of acidity. Opt for an iterative approach and check the pH for multiple proofing times. Find the pH the value that creates the best bread for you. Once you have identified your perfect pH value you can resort to that number on all following doughs. See Table 7.4 for some sample pH values to follow.

7.14 Scoring

Once your dough is done proofing, it's time to warm up your oven to around 230 °C (446 °F). The next step is then to proceed with scoring your dough.

Scoring is done for two reasons. There is functional and decorative scoring. Functional scoring refers to making a small incision in the dough through which it rises while baking. If the dough is not scored, it would likely crack open at the weakest spots where you sealed the dough after shaping. Decorative scoring can be used to apply artistic patterns to your dough and make it more appealing. When you want to apply artistic scoring, it is best to rub your dough with additional rice flour before scoring. The white rice flour greatly boosts the contrast of the scoring incisions and thus makes the final pattern look more visually appealing.

When using a banneton, the dough is flipped over and placed on an oven rack, tray, stone, steel, or dutch oven. The pros and cons of the different baking options are covered in the next chapter. The dough's top side which was previously at the bottom of the banneton should now be facing you.

Figure 7.21: The ear is a characteristic that can be achieved on wheat sourdough when fermenting and scoring your dough with the perfect technique. It offers additional flavor and great texture when eating the bread.

Figure 7.22: A loaf by Nancy Anne featuring an artistic scoring pattern. The high contrast was achieved by rubbing the dough's surface with rice flour before baking. Her Instagram account `simply.beautiful.sourdough` is specialized to showcase beautiful artistic scoring patterns.

The scoring cut for done at a 45° angle relative to the dough's surface slightly off the dough's center. With the 45° angle cut the overlaying side will rise more in the oven than the other side. This way you will achieve a so-called *ear* on the final bread. The ear is a thin crisp edge that offers intriguing texture when eating. The thin edge is typically a bit darker after baking and thus offers additional flavor. In my opinion, the ear turns a good loaf into a great loaf.

The actual incision is done with a very sharp knife, or better, a razor blade. You can

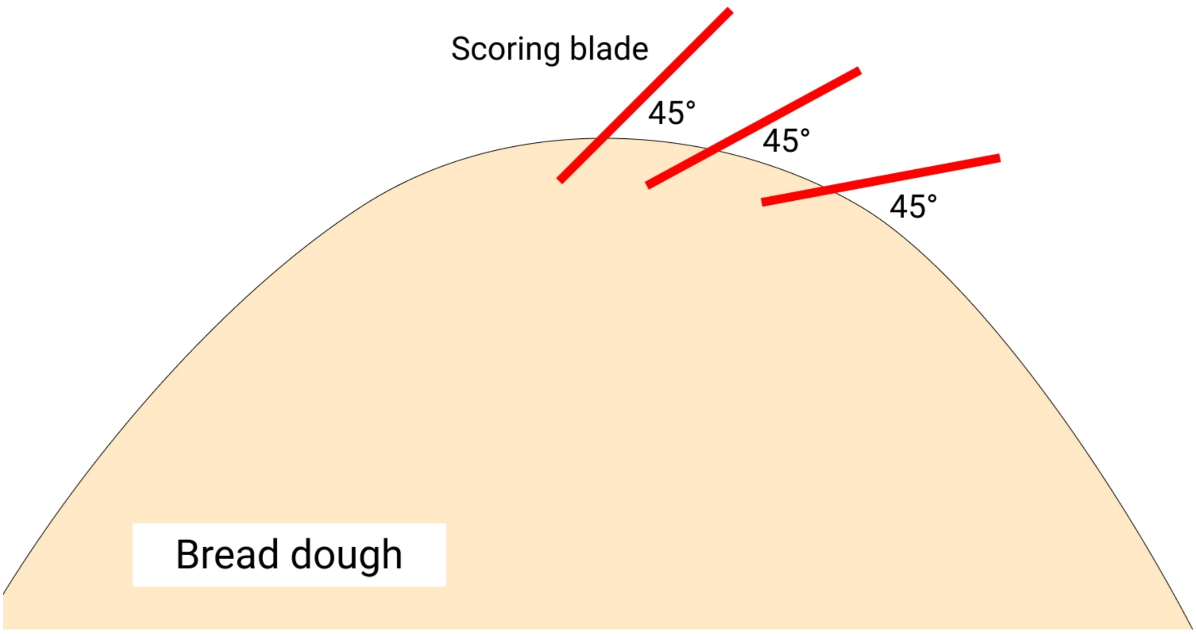


Figure 7.23: The 45° angle at which you score the dough is relative to the surface of the dough. When scoring more towards the side, you have to adjust the angle to achieve the ear on your bread.

use the razor blade directly or attach it to a chopstick. The razor blade offers better flexibility than the sharp knife. Regardless, the blade should be as sharp as possible. This way when cutting, the dough is not torn and instead features a clean, non ragged incision.

To simplify scoring, your dough's surface must be dried out a little bit. This way it is a lot easier to make the incision. For this reason, it is crucial to rub your dough with a bit of flour before placing it in the banneton. The dry flour will absorb some of the moisture of the outer layers of your dough. This is especially important when working with room temperature-proofed doughs. A cold-proofed dough is a lot easier to score due to the dough's low viscosity. The room-temperature dough is a lot harder to score. The scoring incision tears a lot easier. With a ragged incision, the dough is not as likely to properly rise in the oven. Chances are you will not achieve the previously mentioned ear. For this reason, drying out the surface is especially important. Scoring will become a lot easier.

Scoring requires a lot of practice. For this reason, I recommend practicing making the incision after creating dough strength. The dough is going to be very wet and sticky. You can use a sharp knife or razor blade to practice the technique. Wait a few minutes and then round up the dough again. You can practice this for as long as you like until you are happy with your technique. After proofing, you only have a single chance to practice scoring. It's either hit or miss.

An additional trick that can help you to combine the benefits of room temperature-proofing and easy cold-proofing scoring is to place your dough in the freezer for

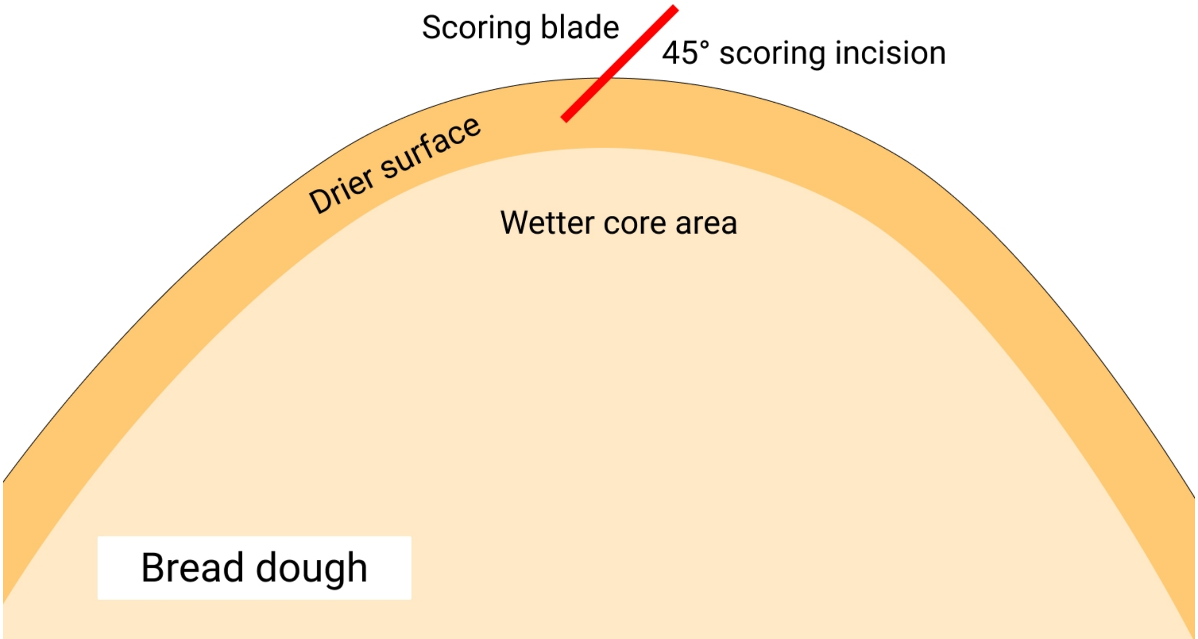


Figure 7.24: By applying flour to your dough's surface after shaping, the outer part of the dough dries out a little bit. This makes scoring a lot easier as the incision is less likely to tear.

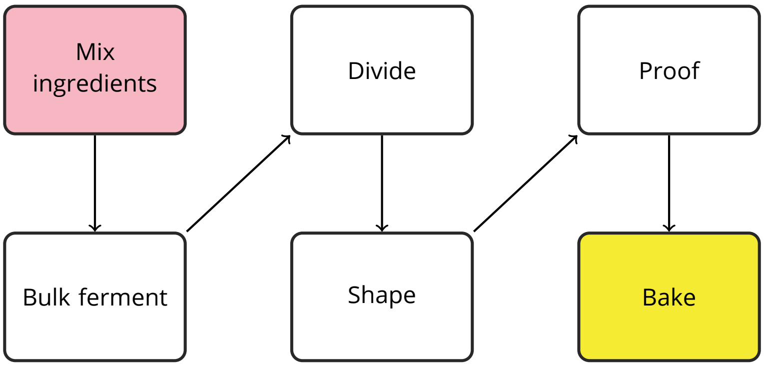
30 minutes before baking. Once you notice your dough is almost done proofing, move it to the freezer. The freezer will dry out the dough's surface even further while also lowering its viscosity, making scoring easier.

Another interesting trick is to bake your dough for 30 seconds without steam. The hot air will dry out the dough's surface even further and simplify the scoring technique. Experiment with the timing to identify your personal sweet spot.

8 Non wheat sourdough

In this chapter you will learn how to make a basic sourdough bread using non-wheat flour, basically all flour except spelt. The key difference between wheat and non-wheat flour is the quantity of gluten, the former feature a high amount of gluten, while the non-wheat flours do not.

The whole process (see Flowchart 8.1) is a lot easier: you mix the ingredients and wait for a certain period until the dough has reached the level of acidity that you like. Afterward, you shape the dough or pour it into a loaf pan. After a short proofing period, the bread can be baked. Due to the lack of gluten development, the final bread will feature a denser crumb compared to wheat, as you can see in Picture 8.4.



Flowchart 8.1: A visualization of the process to make non-wheat sourdough bread. The process is much simpler than making wheat sourdough bread. There is no gluten development. The ingredients are simply mixed together.

For non-wheat flours—including rye, emmer, and einkorn—no gluten development has to be done, meaning there is no kneading, no over-fermentation, and no issues with making flat bread. In the case of rye flour, sugars called pentosans prevent gluten bonds from properly forming [22].

This chapter will focus on making rye bread. The flour could be replaced with einkorn or emmer based on your preference.

Figure 8.1: A sourdough rye bread made using a loaf pan. The rye bread is not scored. The crust typically cracks open during baking.

The following recipe will make you 2 loaves:

1000 g	(100 %)	Whole rye flour
800 g	(80 %)	Water at room temperature
200 g	(20 %)	Sourdough starter
20 g	(2 %)	Salt

The sourdough starter can be in an active or inactive state. If it has been at room temperature for a week with no feedings then it will be okay, same if it has come right out of the fridge then still it will be no problem. The dough is very forgiving.

If you follow the suggested quantities from the recipe you are making a relatively wet rye dough. It's so wet that it can only be made using a loaf pan. If you want to make a freestanding rye bread, consider reducing the hydration to around 60 %.

Mix together all the ingredients with your hands, or opt for a spatula to simplify things. Rye flour itself is very sticky and unpleasant to mix by hand, the dough will stick a lot to your hands. If you use a stiff starter, it could be easier to first dissolve it in the dough's water, then add the other ingredients.

The goal of the mixing process is simply to homogenize the dough, there is no need to develop any dough strength. Once you see that your sourdough starter has been

Figure 8.2: For non-wheat dough the ingredients are mixed together. There is no need to develop any dough strength. This simplifies the whole bread-making process.

properly incorporated, your dough is ready to begin bulk fermentation.

You can bulk ferment the dough for a few hours up to weeks. By extending the bulk fermentation time, you increase the acidity the final loaf is going to feature. After around 48 hours, the acidity will no longer increase. This is because most of the nutrients have been eaten by your microorganisms. You could let your dough sit for longer, but it wouldn't alter the final flavor profile by much.

I recommend waiting until the dough has roughly increased by 50 % in size. If you are daring, you can taste the dough to get an idea of the acidity profile, it will likely taste very sour. However, a lot of the acid will evaporate during the baking process, therefore the final loaf will not be as sour as the dough you are tasting.

Once you are happy with the acidity level, proceed to dividing and shaping your dough. If you made a drier dough, use as much flour as needed to dry the dough a little bit and form a dough ball. There is no folding the dough. All you do is tuck it together as much as is needed to apply the shape of your banneton.

Shaping might not be possible if you opt for the wetter dough. Carefully spread the dough with a spatula in your greased loaf pan, wetting the spatula to make this process easier. Spread it until the surface looks smooth and shiny.

Figure 8.3: Rye flour has a sugar molecule known as pentosan. These pentosans prevent the rye flour from building gluten bonds. As a result the dough never features an open crumb and is always very sticky when hand mixing.

For proofing, I recommend waiting around 60 minutes. An extended proofing period does not make sense unless you want to further increase the dough's acidity. The dough will not become fluffier the longer you proof. With the short proofing period, however, the dough will become a bit more homogeneous. This way the final bread looks more uniform. The proofing period also allows the dough to fully extend and fill the edges of the loaf pan. I also like to move the dough to the fridge for proofing. The dough stays good in the fridge for weeks. You can proceed and bake it at a convenient time for you.

Once you are happy with the proofing stage, proceed and bake your dough just like you'd normally do, more details can be found in Chapter 10. One challenging aspect of using a loaf pan is to make sure that the center part of your dough is properly cooked. For this reason, it is best to use a thermometer and measure the internal temperature. The bread is ready once the internal temperature reaches 92 °C (197 °F). I recommend removing the bread from the loaf pan once it reaches the desired temperature, then continue baking the loaf without the pan and steam. This way you achieve a great crust all around your loaf, and can bake as long as you like until you have achieved your crust color of choice. The darker, the more crunchy the crust and the more flavor it offers. If you feel your dough might have been overly acidic you can extend the baking

Figure 8.4: The crumb structure of rye bread. By making a wetter dough, more water evaporates during the baking and thus the crumb tends to be a bit more open. Generally, rye bread is never as fluffy as wheat sourdough bread. The crust of this bread is a bit pale. The crust color can be controlled by baking the bread for a longer period.

time, as the longer you bake, the more acidity will evaporate.

This is one of my favorite breads to bake which I eat on an almost daily basis. The effort required to make bread like this is much lower compared to a wheat-based dough. In some cases, I extend the recipe and add additional sourdough discard to the dough. You can add as much discard as you like. The resulting bread will have a very complex but delicious flavor profile.

9

Mix-ins

In this chapter, you will learn about the fascinating world of sourdough mix-ins. Discover how these additions can elevate your bread, enhancing flavor, adding vibrant colors, and creating delightful textures that make each loaf a culinary masterpiece.

Figure 9.1: These soft pull-apart sourdough buns have been made with the addition of pumpkin purée. The mashed pumpkin adds flavor and hydration to the dough.

A loaf of wheat sourdough has a very pure aesthetic. Good craftsmanship and precision transform the ingredients into simple, but delicious food. With mix-ins, the basic recipe can become the starting point for a whole world of modifications to try and combine. Think of the loaf of bread as a blank canvas to express yourself.

9.1 Categories

Figure 9.2: A common mix-in technique is to replace some of the dough's water with another liquid. In this case, puréd pumpkin replaced some of the water. When adding puré to the dough only slowly add additional water as the puré slowly releases additional water to the dough.

One approach to categorizing the mixins is to look at their respective shape. However, the transition between these categories is somewhat fuzzy:

- Liquids: Integrate homogeneously into the dough, may replace some of or all of the water. Examples: Milk, butter, oil, spinach juice, tomato juice, eggs
- Powders: Integrate homogeneously into the dough, may replace some of the flour. Examples: Milk powder, semolina, cocoa, spices
- Small bits: Individually visible in the final loaf, small enough to distribute somewhat evenly throughout the dough. Examples: Seeds (wheat berries, rye berries, poppy seeds, sesame, pumpkin seeds, flax seeds), whole spices (coriander)

- Chunks: Larger pieces that will only be present in the occasional bite when eating a slice of your bread. Examples: dried tomatoes, chunks of cheese, chunks of chocolate

Another categorization approach looks at the changes to the bread:

- Flavor: Significantly changes the taste of the bread. Examples: rye flour, corn flour, spices, sugar.
- Color: Significantly changes the look of the bread. Examples: cocoa, squid ink, beetroot juice, tomato juice.
- Texture: Significantly changes the feeling in the mouth when eaten. Examples: Cheese (gummy), seeds (crunchy), olives (squishy chunks).

Many of the above-listed mix-ins can't be pinpointed to a single category. They change multiple aspects of the final bread at the same time.

Figure 9.3: In this case a combination of flax, sunflower and sesame was added to the dough. The seeds will slightly dehydrate the dough during fermentation and thus adding a bit more water (1 % to 2 %) is advised.

Mix-ins affect the structure of the dough. One aspect is the impact on hydration. Some mix-ins absorb a lot of water when added to the dough, so you have to increase the amount of water to achieve the same dough consistency. The other impact is on the gluten network. Bits and chunks disrupt the gluten network and may reduce oven spring during baking. All of this depends on the amount of mix-ins used. A good rule of thumb is to add 10 % to 20 % of the amount of flour in most mix-ins, reduced to around 1 % to 5 % of the amount of flour for spices.

An important factor is also the mix-in's behavior during baking. Particularly chunks may bake differently than dough, and either melt (cheese) leaving holes inside, or char when peeking through the crust (*e.g.* vegetables). These problems can be mitigated to some degree with the right preparation (*e.g.* chopping into smaller pieces, soaking dry ingredients in water or oil first, or squeezing out excess moisture).

9.2 Examples

The following is a list of common mix-ins and their peculiarities. They can be combined depending on your preference.

9.2.1 Flours

These are powders. Usually, you want to just replace some fraction of the regular bread flour. Different flours change the taste of the bread and usually moderately affect the color.

- Whole wheat flour (substitute any amount, makes the bread taste more complex, nutty)
- Rye flour (very hearty, nutty, malty taste)
- Enzymatic malt (malty taste, improves enzymatic activity). The malt is a great addition when making quicker yeast-based doughs.
- Semolina (supports Mediterranean flavors)
- Cocoa (replace 10 % of the flour for a black loaf, goes great with sweet toppings)
- Other non-wheat flours such as: Chickpea, corn, hemp, potato...

9.2.2 Liquids

Instead of using water, you can substitute it with a different liquid, affecting taste and texture.

- Beer
- Butter

Figure 9.4: Broa de milho is a traditional Portuguese bread made out of half rye and half corn flour.

- Buttermilk
- Cereal milk (the leftover milk from eating cereals)
- Coffee
- Eggs
- Fruit/vegetable juices (also see Section 9.2.3)
- Milk (for sweet, soft breads)
- Milk alternatives such as: Almond, oat, soy...
- Mashed potatoes
- Mashed sweet potatoes. Bolo do caco is a typical bread from Madeira, made from 50 % wheat flour and 50 % mashed potatoes.
- Olive oil (Mediterranean)

Figure 9.5: Dark hearty stouts work excellently as a water replacement when making sourdough bread. The resulting loaf features a hearty malty taste

- Other mashed vegetables such as: Beets, pumpkin...

9.2.3 Colors

Some mix-ins will change the color and flavor of your bread. Common colorings include:

- Activated charcoal powder (black)
- Beetroot juice (red)
- Blueberry juice (blue)
- Blue butterfly pea flower powder (blue)
- Carrot juice (orange)
- Pear juice (pink)
- Spinach juice (green)
- Squid ink (black)

- Strawberry juice (red)
- Tomato juice (red)

9.2.4 Seeds and nuts

These are small bits, with some almost crossing into the chunk category. Some seeds benefit from being boiled for about 10 minutes before adding them to the dough.

Figure 9.6: The Stollen is a traditional German sweet Christmas bread featuring a variety of mix-ins. The dough typically contains candied lemon, candied orange, and raisins. The mix-ins are soaked in rum before being added to the dough. While the stollen matures after baking (up to 6 months) the candied ingredients release their aroma to the baked product.

- Cacao nibs
- Chia seed
- Chopped or whole nuts such as: Almonds, hazelnuts and walnuts
- Flaxseeds
- Hemp seed
- Poppy seed

- Pumpkin seed
- Sesame
- Sunflower seed
- Whole rye berries (boil 10 minutes)
- Whole wheat berries (boil 10 minutes)

Figure 9.7: A sourdough bread made with half whole-rye flour and half rye berries. The berries are typically boiled for 10 minutes to allow them to soften a bit. When baking a loaf it is advised to use a thermometer to measure whether it is done baking. The final bread features a hearty tangy flavor and has a moist crumb.

9.2.5 Spices and flavor mix-ins

These are mostly powders or small bits.

- Blueberry skins (press through a sieve to remove juice), raw blueberries
- Browned onions

- Candied fruits such as: Lemon, orange, pineapple...
- Cinnamon
- Grated hard cheese such as: Gruyère, parmesan...
- Mediterranean herbs such as: Marjoram, oregano, rosemary, thyme...
- Miso
- Molasses
- Sugar
- Spices such as: Anise, fennel, cinnamon, coriander, cumin...
- Zests such as: Lime, Lemon, orange...

9.2.6 Highlights

Mostly chunks, that add a big contrast and flavorful highlight to the basic bread. Usually, you want to use only one (or a maximum of two) of these. The suggestions can often be complemented by some flavor or flour mix-in.

- Chocolate chunks or drops
- Chunks of black garlic
- Chunks of cheese such as: Cheddar, feta...
- Cornflakes
- Dried fruits such as: Cranberries, dates, raisins...
- Olives
- Pickled pepperoni
- Sun-dried tomatoes (squeeze out the oil if using pickled ones, or soak dried ones in water)

9.2.7 Combinations

A few combinations where multiple mix-ins complement each other:

- Butter and milk. Then add cinnamon and brown sugar before shaping
- Cheddar and pepperoni
- Cheddar and jalapeño
- Cocoa, cacao nibs, whole hazelnuts
- Cranberry and walnuts
- Semolina, Mediterranean herbs, olives, sun-dried tomatoes
- Tomato juice instead of water with 20 % rye flour

9.3 Techniques

Adding mix-ins to the dough is just the simplest approach. Add the mix-ins directly when you knead the dough. After the first kneading wait for 30 minutes to see if the dough has enough or too much water. In the case of whole-soaked berries (*e.g.* rye or wheat) chances are that the berries will release some water and make the dough wetter. In this case, you will want to add a bit more flour to the dough to compensate for the high hydration.

9.3.1 Adding before shaping

Another approach is to lay the dough out flat after the bulk fermentation. Then using a spatula spread your ingredient over the flat dough. Continue with your regular shaping and/or roll up the dough. When creating a roll you can use a sharp knife to cut the dough, dental floss works great too. Afterward, place the tiny swirls in a container to let them proof and become fluffier. This is an excellent way to add sweet mixins as the microbes will not ferment them. When adding sugar to the initial dough it will be fermented and the resulting dough will not taste sweet (depending on the fermentation duration). This approach is excellent for garlic/cheese rolls, garlic/herb rolls, and cinnamon rolls

Figure 9.8: A great technique is to add some of your mix-ins directly before shaping. In this case, a mixture of apples, cinnamon and brown sugar was applied. Proceed and roll the dough together. Afterward cut the roll into smaller pieces using a sharp knife, dough scraper or dental floss. Place each piece of dough next to each other in a greased bowl to allow them to be proofed. Proceed and bake as you would normally do. The benefit of this technique is that the mix-ins will not be fermented. This is typically required in the case of sugar since you want the final baked goods to feature sweetness. If included upon initial mixing most of the sugar would be fermented and the bread would not taste sweet.

9.3.2 Covering the surface

This works best for either powders or small bits. After shaping wrap your coverings on the dough's surface. This works great too when covering your banneton or loaf pan with seeds or oats. When using a loaf pan or banneton these coverings also help to make the container stick less.

Another approach commonly used with buns is to wet the surface or dump the dough in water. Afterward, dip the wetted piece of dough into your bowl of mixins. This does not work for all mix-ins, as some can't handle the high temperatures during baking and char. Most commonly done with seeds (*e.g.* sesame, oats, flax-seed).

Figure 9.9: These are chop buns which are created by chopping up a retarded dough into smaller pieces before baking. Then each piece of dough is quickly dumped in water and then rolled in a bowl of seeds. Afterward, the dough is directly baked in the preheated oven. These coverings add superb additional flavor and can be adjusted depending on your preference. I love adding a mixture of sunflower, flax, and sesame seeds.

9.3.3 Swirled colors

Mix-ins that change the color of the dough bring the opportunity for even more creativity by merging the dough before shaping.

Proceed and separate your base dough before adding a colorful ingredient. Bulk ferment the dough in separate containers. Then Combine the two (or more) differently colored doughs by laminating and stacking the colored sheets of dough before the last folding, just before shaping. This way the colored layers won't mix and the resulting dough will have differently colored and tasting layers.[1]

[1] I once made an experimental dough by merging a wheat, rye, spelt and einkorn dough into a single dough. The resulting dough was layered featuring different colors, textures, and flavors.

10
Baking

Baking refers to the part of the process where you are loading your dough into the oven.[1] Baking is typically done after your dough has gone through the bulk fermentation and proofing stage. This chapter will review what happens to your dough during baking, as well as several techniques used to improve the final result.

10.1 The process of baking

Once temperature starts to rise, the dough will go through several stages as summarized in Table 10.1. As the dough heats up, the water and acids in your dough start to evaporate. When baking a gluten based dough, the bubbles in your dough start to expand. The dough starts to vertically rise, this is called oven spring. Your bread starts to build a crust of gel-like consistency, the crust is still extensible and can be stretched.

At around 60 °C (140 °F) the microbes in your dough start to die. There are rumors that until this happens the microbes produce a lot of CO_2, resulting in the dough's expansion. However, this temperature is reached quickly. Furthermore, stress makes the microbes enter sporulation mode in order to focus on spreading genetics. More research should be done here to validate or invalidate this claim.

At 75 °C (167 °F) the surface of your dough turns into a gel. It holds together nicely but is still extensible. This gel is essential for oven spring as it retains the gas inside your dough.

At around 100 °C (212 °F) the water starts to evaporate out of your dough. If this weren't the case, your dough would taste soggy and doughy. The higher hydration

[1]While some breads like flatbreads could also be baked on the stove. This chapter focuses on the home oven.

°C / °F	Stage	Description
60 / 140	Sterilization	The temperature is too hot for your microorganisms and they die.
75 / 167	Gel building	A gel builds on the surface persisting your dough's structure. It is still extensible and can spring in the oven.
100 / 212	Water evaporation	Water begins to evaporate and inflates your dough's alveoli.
118 / 244	Acetic acid evaporation	The vinegary tasting acid starts to evaporate, sourness decreases.
122 / 252	Lactic acid evaporation	The dairy tasting lactic acid begins to evaporate, sourness further decreases.
140 / 284	Maillard reaction	The Maillard reaction starts to deform starches and proteins. The dough starts browning.
170 / 338	Caramelization	Remaining sugars begin to caramelise giving your bread a distinct flavor.

Table 10.1: The different stages that your dough undergoes during the baking process.

your dough has, the more water your bread still contains after the bake, changing its consistency. As a result the crumb is going to taste a bit more moist.

Another often undervalued step is the evaporation of acids. At 118 °C (244 °F) the acetic acid in your dough starts to evaporate. Shortly after at 122 °C (252 °F) the lactic acid begins evaporating. This is crucial to understand and it opens the door to many interesting ways to influence your final bread's taste. As more and more water begins to evaporate the acids in your dough become more concentrated. There is less water but in relation you have more acids, therefore a shorter bake will lead to a more tangy dough. The longer you bake the bread, the more of the water evaporates, but also ultimately the acids will follow. The longer you bake, the less sour your bread is going to be. By controlling baking time you can influence which sourness level you would like to achieve.

It would be a very interesting experiment to bake a bread at different exact temperatures. How would a bread taste with only evaporated water but full acidity? What if you were to just completely get rid of the acetic acid? How would the taste change?

As the temperature increases further the crust thickens. The Maillard reaction kicks in, deforming proteins and starches. The outside of your dough starts to become browner and crisper, this process begins at around 140 °C (284 °F)

Once the temperature increases even more to around 170 °C (338 °F), the caramelization process begins, the remaining sugars and the microbes which did not convert yet start

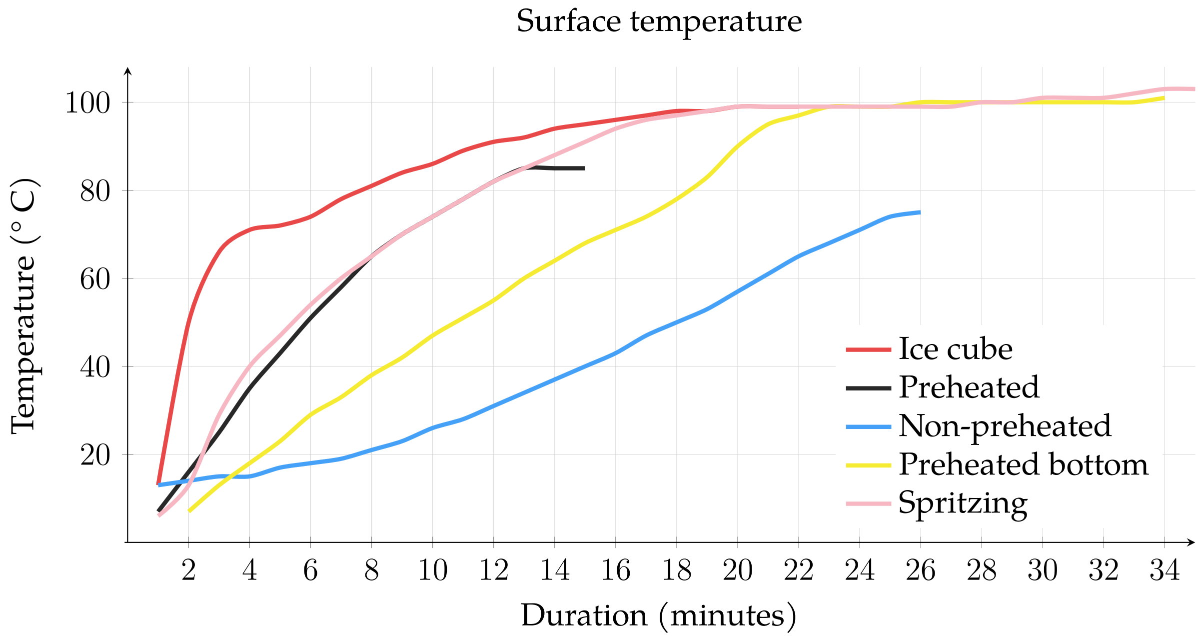


Figure 10.1: This chart shows how surface temperatures change using different steaming methods. In this case I used a Dutch oven and an apple as dough replacement. All the apples were coming from the fridge. The temperature was measured using a barbecue thermometer. The more steam, the faster the apple's surface temperature increases.

to brown and darken. You can keep baking for as long as you like to achieve the crust color that you like.[2]

The best method to know that your dough is done is to take the temperature of your dough, you can use a barbecue thermometer to measure it. Once the core temperature is at around 92 °C (197 °F), you can stop the baking process. This is typically not done though as the crust hasn't been built yet.[3]

Once your dough has finished baking, it is ready to eat: your dough has turned into a bread. At this point, your bread is sterile as the temperature was too hot for for the microorganisms to survive.[4]

[2]This really depends a lot on your personal preference. Some people prefer a darker crust, others prefer a more pale crust. It's better to build less crust than too much. You can always just heat your bread in the oven one more time to continue building a darker crust.

[3]The thermometer is especially important when using a large loaf pan. It is sometimes very hard to judge from the outside if the dough is done. I failed many times and ended up having a semi baked dough.

[4]I wonder though if a starter culture could be grown again from a slice of bread. Under heat stress the microorganisms begin sporulating. Maybe some of the spores survive the baking process and could be reactivated later? If this works, you could use any store bought sourdough bread as a source for a new starter.

10.2 The role of steam

Steam is essential when baking as it helps to counter premature crust building. During the first stage of the bake, the dough increases in size as the water in your dough evaporates and pushes the whole dough upwards.

Normally, under high heat a crust would form. Just like if you were to bake vegetables in your home oven, at some point they become darker and crisper. This is the same thing that happens with your dough, and you want to delay this process as long as possible until your dough no longer expands. Expansion stops when most of the microbes have died and the evaporating water no longer stays inside the alveoli.

The stronger the gluten network, the more gas can be retained during the baking process. This gluten network at some point loses its ability to contain gas as the temperature heats up. The dough stops increasing in size. The steam plays an important role as it condenses and evaporates on top of your dough. The surface temperature is rapidly increasing to around 75 °C (160 °F). At this temperature the gel starts to build, and is still extensible and allows expansion. Without the steam, the dough would never enter the gel stage, but instead directly go to the Maillard reaction zone. You want your dough to stay in this gel stage as long as possible to achieve maximum expansion.[5]

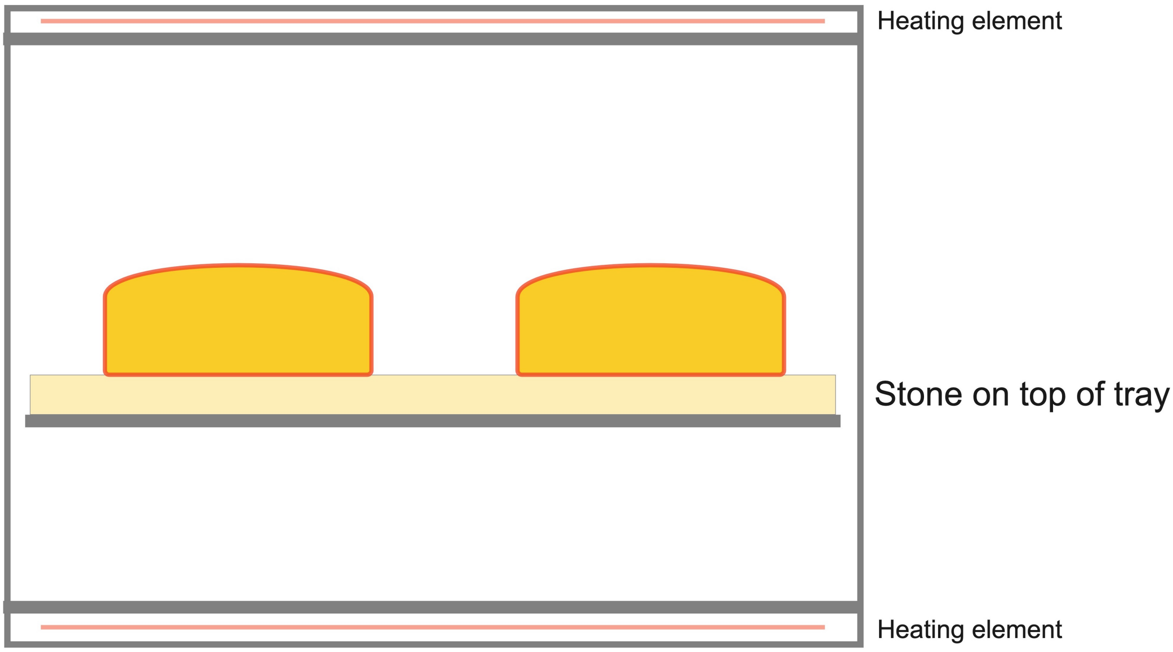


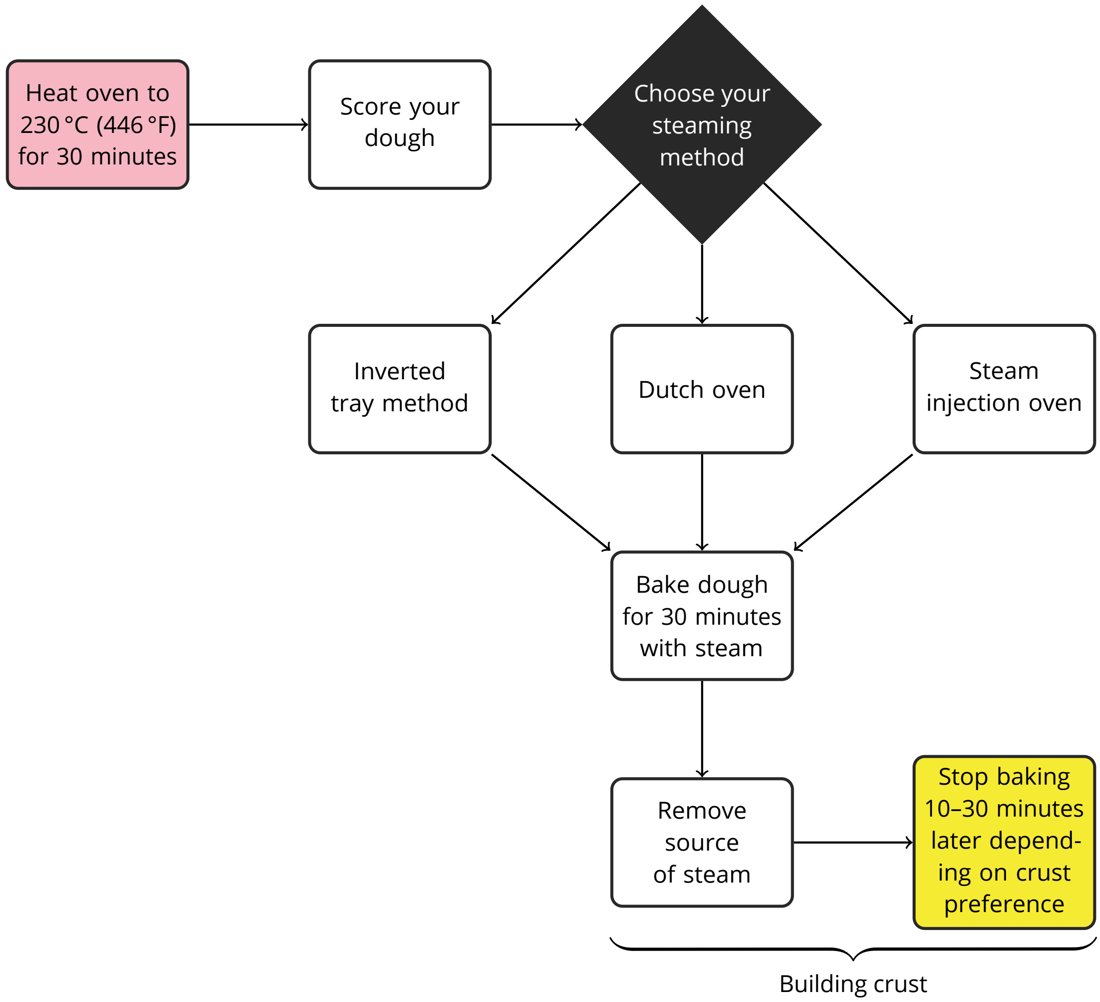
Figure 10.2: The second stage of the bake is done without steam to build a thicker, darker crust.

[5]You can remove your dough from the oven after 5 minutes to see the gel. You will notice that it holds the dough's structure and it has a very interesting consistency.

When not steaming enough, you will notice that the scoring incisions do not properly open up during the bake. They stay closed as the dough is unable to push through the crust. Another common sign, as you can see in Figure 10.3 is that you have larger pockets of air towards the crust of your dough. As the dough increases vertically, expansion is halted by the crust. The pockets of air converge into larger pockets as the pressure increases. This can also happen when you are baking at too high a temperature.

The more you steam, the softer your dough's crust is. You will never enter the Maillard and caramelization stage. This is the reason why the source of steam is removed for the second stage of the bake. No more expansion can happen and you can focus on building a crust. If you would like a soft crust, you can steam your dough all the way.

Figure 10.3: A submission by Karomizu showing a bread that has been baked at too high a temperature or with too little steam. Note the large pockets of air towards the crust. They are a typical indicator.



Flowchart 10.1: A schematic visualization of the baking process using different sources of steam in a home oven.

10.3 Building up steam

10.3.1 Dutch ovens

Dutch ovens are an ideal way to bake with a lot of steam. They are not fully sealed. Regardless though, as water evaporates from your dough, it will create a steamy environment allowing your dough to rise. It makes baking in a home oven very easy.

When using a Dutch oven, make sure to preheat it properly, this way your dough will not stick to it. You can also use additional semolina flour or parchment paper. Another good trick is to spritz your dough with a bit of water. To create more steam, you could also place a small ice cube next to your main dough.

Figure 10.4: My default home oven setup. The tray of rocks and tray on top of the rolls greatly improve the steaming capabilities. This way the bread can rise more during the initial stage of the baking process.

I have been using a Dutch oven myself for a long time. They have issues though. They are relatively heavy. It is dangerous to operate hot cast iron ovens. Especially when working with steam, you have to be very careful. Furthermore, they are expensive to buy. If your Dutch oven is made out of cast iron you have to season it from time to time. This takes time.

The biggest disadvantage, though, is capacity. You can only bake a single piece of bread at a time, as the size of the Dutch oven is limited. In many cases, it makes sense to bake multiple loaves in one go. It makes the whole process more efficient as you have to knead less per loaf. The time it takes to make one loaf is significantly reduced on average. Furthermore, you don't require as much energy. You don't have to preheat your oven twice for each loaf.

An additional disadvantage of Dutch ovens is the need to move very hot and heavy cast iron.[6] You will need to be very careful and ideally use heat-resilient gloves when

[6] Some of them can weigh up to 10 kg. Moving them is quite a tedious exercise. Especially if the cast iron is heated you have to be very concise with your movements. Despite doing my best I have a few scars on my hands and arms from operating the Dutch ovens.

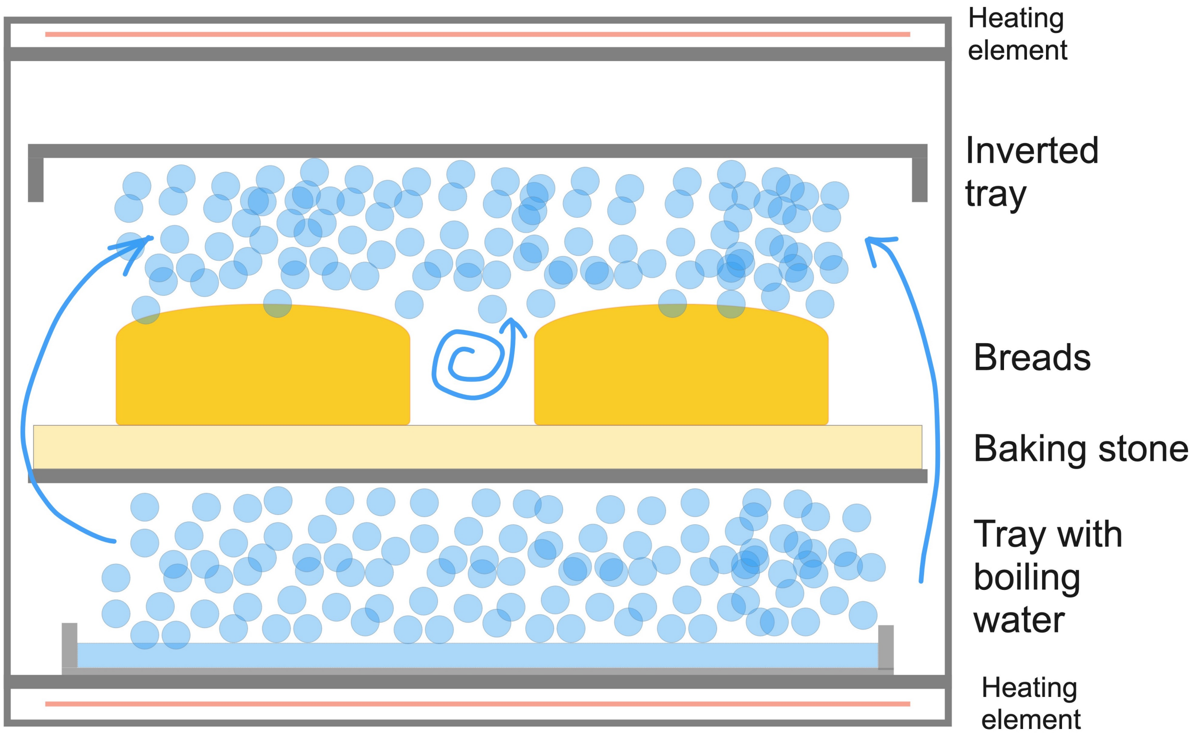


Figure 10.5: How steam builds in your oven using the later described inverted tray method.

touching your Dutch oven.

Furthermore, some of the Dutch ovens come at a hefty price tag. Especially for new bakers buying a Dutch oven on top of other tools can be quite a hefty investment. For this reason, I advocate the inverted tray method visualized in the next section. In case you do not own an oven consider trying the simple flatbread recipe which is baked in a pan. Please refer to Section 6.2.2 for more details.

10.3.2 Inverted tray method

The inverted tray method simulates a Dutch oven. By placing another tray on top of your dough, the steam created from the dough and water source stays around your dough.

The biggest advantage of this method compared to the Dutch oven is scalability. You can bake multiple loaves at the same time. In my case that is around 2 freestanding loaves and 4 loaves in a loaf pan.

For the inverted tray you will need the following tools:

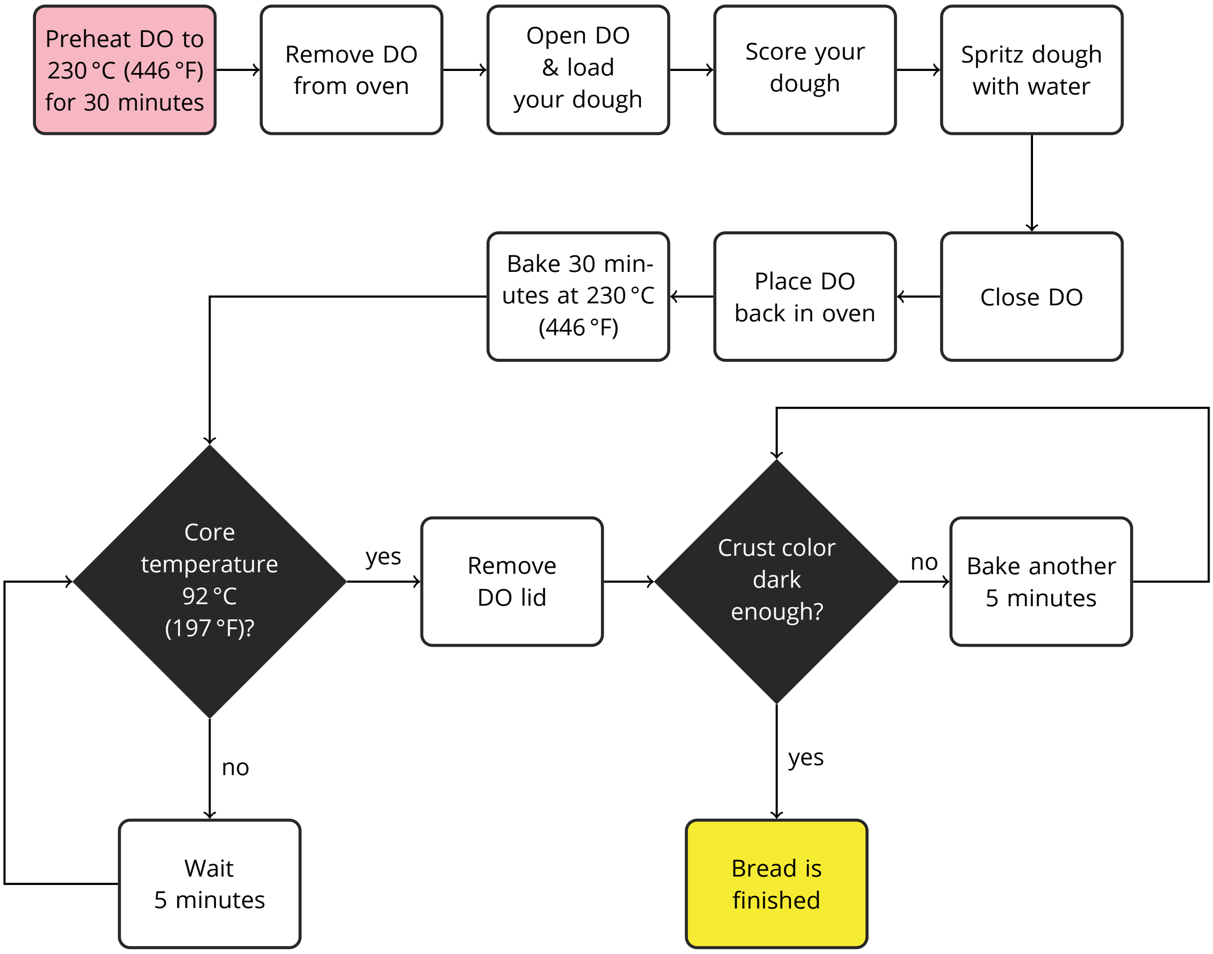
- 2 trays
- 1 heat resistant bowl

Figure 10.6: An example of a dutch oven. Some are also made out of enameled cast iron, others are made out of clay and some feature a glass lid. They all work similarly by entrapping some of the steam created during the baking process. The steamy environment allows the bread to rise further and thus have more oven spring and feature a fluffier crumb.

- Boiling water
- Oven gloves
- (Optional) Parchment paper

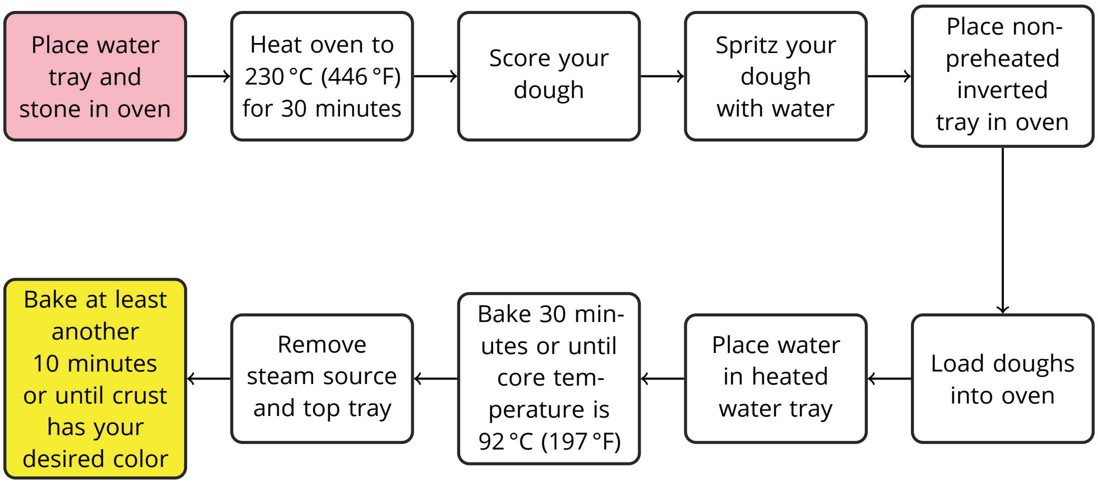
These are the steps to follow with the inverted tray method:

1. Preheat the oven to around 230 °C (446 °F) and preheat one of the trays.
2. Bring water to boil.
3. Place your loaves on a piece of parchment paper. You can also place each on a tiny piece of parchment paper. This makes loading the dough easier. If you don't have it or don't want to use it, you can opt for semolina flour. It helps to make the tray nonstick.
4. Take out your hot tray and place it on a cooling rack or on something else that is heat resistant.
5. Score your doughs.



Flowchart 10.2: A visualization of the baking process using a dutch oven (DO). The dough is steamed for the first half of the bake and then baked without cover for the second half of the bake. The desired darkness and thickness of the crust depends on your personal preference. Some bakers prefer a lighter crust and others a darker.

6. Place your doughs on the hot tray.
7. Place the cold tray in your oven in an inverted position.
8. Move your hot tray including the loaves back to the oven.
9. Place the boiling water in the heat-resistant water bowl. I have added rocks to it, as it helps to improve the steam even further. This is optional.
10. Close the oven.
11. After 30 minutes remove the top tray. Also remove the bowl with water.



Flowchart 10.3: A schematic visualization the inverted tray baking method that works great for home ovens.

Figure 10.7: My home oven setup.

12. Finish baking your bread until you have reached your desired crust color. In my case this is another 15–25 minutes typically.

10.4 Conclusions

Oven type	Plain (no tools)	Inverted tray	Dutch oven
Gas	No	No	Yes
Convection (Fan always on)	No	No	Yes
Convection (Fan can be disabled)	No	Yes	Yes
Steam	Yes	Yes	Yes

Table 10.2: An overview of different oven types and their different baking methods.

Depending on your home oven, a different method of steaming may be used. Generally most ovens are made to vent out most of the steam during the bake. They are typically not fully closed. During baking you want to dry out whatever you are baking. This is ideal if you are roasting vegetables and want them to dry out. For baking though, this is highly problematic. As described earlier, you want there to be as much steam as possible.

If you are using a gas-based oven, the only option is to utilize a Dutch oven. The same is true when you are using a convection oven with a fan that cannot be disabled. When using a convection oven with a fan that can be turned off, you can opt to use the cost-efficient inverted tray method.

If you are in the luxurious position of owning a steam oven, things are easier. Just activate the steam function and you are good to go. Placing an additional tray on top of your dough during the bake helps to bake with indirect heat. You remain in the gel zone longer and will experience more oven spring.

11

Storing bread

In this chapter you will discuss different methods of storing your bread, each with their own pro and cons. This way your bread can be best enjoyed at a later time.

A summary can be found in Table 11.1, with details and explanation in th rest of this chapter.

Method	**Advantages**	**Disadvantages**
Room temperature	The easiest option. Best for bread that is eaten within a day. Crust typically stays crisp when humidity not too high.	Bread dries out very quickly.
Room temperature in airtight container	Good for up to a week.	Bread needs to be toasted for crust to become crisp again. Catches mold more quickly
Fridge	Bread stays good for weeks. Can dry out a little bit when not using air-tight container.	Bread needs to be toasted. Requires fridge and energy.
Freezer	Bread stays good for years.	Requires thawing and then toasting. Requires freezer and energy.

Table 11.1: A table visualizing the advantages and disadvantages of different bread storing options.

11.1 Room temperature

The most common method is to store your bread at room temperature. After taking a slice of bread, store your bread with the crumb facing side downwards.

This method works great if you want to eat your bread within a day. The crust stays crisp and does not become soft.[1] The biggest downside to this method is that the bread becomes hard quickly. As time progresses, more and more water evaporates from your dough's crumb. Ultimately, the bread will become very hard and impossible to eat. The more water you use to make the bread, the longer the bread stays good. A low-hydration recipe can dry out after 1–2 days; a high-hydration bread needs 3–4 days to dry out.

Once your bread has dried out, you can run it under tap water for around 10 to 15 seconds. This water bath allows the crumb's starch to absorb a lot of water. Proceed and bake your bread again in the oven. The resulting loaf will be almost as good as new again.

Another option for dried-out bread is to use it to make breadcrumbs. These bread crumbs can be mixed into subsequent loaves. They can also be used as base ingredients for other recipes such as *Knödel*.[2]

11.2 Room temperature in a container

Just like the previous option, you can also store your bread inside a container. This could be a paper bag, a plastic bag, or a bread storage box. The paper bag and most bread boxes are not fully sealed, allowing some of the air to diffuse out of the container. This also means that the bread will slightly dry out.

When using a sealed bag such as a plastic bag, the bread will retain a lot of moisture. The bread will stay good for a longer period. However, at the same time, the crust will also lose its crispness. Some of the water diffuses into the bag and is then re-absorbed by the crust. If you want the crisp crust, the best option is to toast your bread.

Another problem with storage containers is natural mold contamination. The moment your bread is taken out of the oven it starts being contaminated with aerial mold spores. The spores are microscopically small and are everywhere. The mold spores grow best in a humid environment. By placing your dough in a container you have created a mold paradise. A plain yeast-based dough will start to mold within a few days like this. The sourdough-based bread stays good for a longer period as the acidity is a natural mold inhibitor.

[1] The higher the humidity in your room, the faster the crust will become soft.

[2] *Knödel* is an Austrian dish that uses old bread as a basis. Breadcrumbs and day-old bread are mixed with eggs, and sometimes spinach or ham are added. The batter is then boiled in salty water.

11.3 Fridge

In my own experience storing bread inside the fridge works well as long as you use a sealed container, even if some sources say that the bread dries out inside of the fridge [16]. Supposedly the fridge encourages liquid from the crumb to migrate to the bread's surface.

In my experience though, the trick is to use a sealable container. With a sealable ziplock bag, the excess humidity will stay in the bag and ensures that the bread does not dry out as quickly. At room temperature, this would cause your bread to mold. At lower temperatures, the bread can stay good like this for weeks. The crust however, will lose its crispness and thus toasting is advised.

11.4 Freezing

Another great option for long-term storage is to use your freezer. Slice up the whole loaf and create portions that you can consume within a day. Store each portion in a separate container and place them inside your freezer.

When you want to eat fresh bread, open one of the containers in the morning and allow the bread to thaw over a few hours. This is needed so you can easily separate the frozen-together slices. Toast the slices in your toaster or bake them in the oven until they have the crispness that you like.

This option is great for very long-term storage. Personally I like having a few slices of bread frozen as an emergency backup when I have had no time to bake.

A 2008 study hints that there might be some health benefits to freezing and toasting your bread. By doing so the starch molecules could become more resistant to digestion and thus lower your body's blood sugar response by almost 40% [23].

12 Troubleshooting

You could consider this chapter as an FAQ about most problems faced by bakers, it should give you the debugging tools you need to analyze the situation. You can then apply the appropriate measures and squash each *bug* one by one until you reach the perfect loaf.

12.1 Starter

12.1.1 My starter does not double in size

Some bakers call for the sourdough starter to double in size before using it. The idea is to use the sourdough starter at peak performance to ensure a balanced fermentation in the main dough.

The doubling in size metric should be taken with a grain of salt when judging your starter. Depending on the flour you use to feed the starter, different levels of its rising can be expected. For instance, if you use rye flour then only very little gas from the fermentation can be retained inside the starter. In consequence, your sourdough starter will not rise as much. It could still be in healthy shape. If you use wheat flour with less gluten, the starter will not rise as much either. The reason is that you have a weaker gluten network resulting in more gas dispersing out of your dough.

That being said, it is recommended that you develop your volume increase metric. Your starter will increase in size and then ultimately lose structure and collapse. Observe the point before it collapses. This is the point when you should use your starter. This could be a 50 % volume increase, 100 percent or 200 %. It is always better to use the starter a little bit too early rather than too late. If you use the starter later, reduce the quantity that you use. If the recipe calls for a 20 percent starter quantity, use only 10 percent starter in that case. Your starter will regrow in your main dough.

On top of relying on the size increase, start taking note of your starter's smell. Over time you will be able to judge its fermentation state based on the smell. The stronger the smell becomes, the further your dough has fermented. This is a sign that you should use less starter when making the actual dough.

Please refer to Section 7.2 "Readying your starter" for more information on the topic.

12.1.2 What's the best starter feeding ratio?

The best starter feeding ratio is commonly either 1:5:5 or 1:10:10. In the case of 1:5:5 that's 1 part old starter, 5 parts flour and 5 parts water. If you are using a stiff starter, use half the amount of water. So that's 1:5:2.5. Depending on when you last fed your starter 1:10:10 might make more sense. If the starter is old and hasn't been fed recently the 1:10:10 ratio is a better choice. By reducing the starter inoculation ratio, you provide the microorganisms with a cleaner environment. This way they can reproduce and regrow into a more desirable balance to begin your dough fermentation.

Generally, think of your sourdough starter as a dough. Use the same ratios you use for your bread dough for your starter. Your starter should be trained in the same environment that you later use for your dough. This way your starter is perfectly suited to ferment the dough into which it is later inoculated.

The only exception to the 1:5:5 and 1:10:10 rule is the initial starter set-up stage. For the first days during the starter-making process there aren't enough microbes yet. So using a 1:1:1 ratio can speed up the process.

12.1.3 What's the benefit of using a stiff sourdough starter?

A regular sourdough starter has equal parts of flour and water (100 % hydration). A stiffer sourdough starter features a hydration level of 50 to 60 %.

The stiff sourdough starter boosts the yeast part of your starter more. This way your gluten degrades slower and you can ferment for a longer period. This is especially handy when baking with lower gluten flours.

You can read more about the topic of stiff sourdough starters in Section 4.4.

12.1.4 What's the benefit of using a liquid sourdough starter?

The liquid starter will boost anaerobic bacterial fermentation in your starter. This way your starter tends to produce more lactic acid rather than acetic acid. Lactic acid is perceived as milder and more yogurty. Acetic acid can sometimes taste quite pungent.

Acetic acid can be perfect when making dark rye bread but not so much when making a fluffy ciabatta-style loaf.

When converting your starter to a liquid starter you are permanently altering the microbiome of your starter. You cannot go back once you have eliminated acetic acid-producing bacteria. So it is recommended to keep a backup of your original starter.

A downside to the liquid starter is the overall enhanced bacterial activity compared to yeast activity. This means the baked bread will have more acidity (but milder). The dough will degrade faster during fermentation. For this reason, you will need to use strong high-gluten flour when using this type of starter.

You can read more about the liquid starter in Section 4.3

12.1.5 My new starter doesn't rise at all

Make sure that you use unchlorinated water. In many areas of the world, tap water has chlorine added to kill microorganisms. If that's the case in your region, bottled spring water will help. You can also use a water filter with activated charcoal which will remove the chlorine. Alternatively, if you draw tap water into a pitcher or other container and let it sit, loosely covered, the chlorine should dissipate within 12–24 hours, and you have the added advantage of automatically having room-temperature water.

Make sure to use whole grain flour (whole-wheat, whole-rye, etc.). These flours have more natural wild yeast and bacterial contamination. Making a starter from just white flour sometimes doesn't work. Try to use organic unbleached flour to make the starter. Industrial flour can sometimes be treated with fungicides.

12.1.6 I made a starter, it rose on day 3 and now not anymore

This is normal. As your starter is maturing, different microorganisms are activated. Especially during the first days of the process, bad microbes like mold can be activated. These cause your starter to rise a lot. With each subsequent starter-feeding, you select the microbes that are best at fermenting flour. For this reason, it is recommended to discard the leftover unused starter from the first days of the process. Later on, unneeded starter amounts should never be thrown away. You can make great discard bread out of it.

So just keep going and don't give up. The first big rise is an indicator that you are doing everything right. Based on my experience, it takes around 7 days to grow a starter. As you feed your starter more and more, it will become even better at fermenting flour. The first bread might not go exactly as you planned, but you will get there eventually. Each feeding makes your starter stronger and stronger.

12.1.7 Liquid on top of my starter

Sometimes a liquid, in many cases black liquid, gathers on top of your sourdough starter. The liquid might have a pungent smell to it. Many people confuse this with mold. I have seen bakers recommending to discard the starter because of this liquid. The liquid is commonly known as *hooch*. After a while of no activity the heavier flour separates from the water. The flour will sit at the bottom of your jar and the liquid will stay on top. The liquid turns darker because some particles of the flour weigh less than the water and float on top. Furthermore dead microorganisms float in this liquid. This liquid is not a bad thing; it's actively protecting your sourdough starter from aerobic mold entering through the top.

Figure 12.1: Hooch building on top of a sourdough starter [50].

Simply stir your sourdough starter to homogenize the hooch back into your starter. The hooch will disappear. Then use a little bit of your sourdough starter to set up the starter for your next bread. Once hooch appears, your starter has likely fermented for a long period of time. It might be very sour. This state of starter is excellent to make discard crackers or a discard bread. Don't throw anything away. Your hooch is a sign that you have a long fermented dough in front of you. Compare it to a 2 year ripened Parmigiano cheese. The dough in front of you is full of delicious flavor.

12.1.8 Fixing a moldy sourdough starter

First of all, making a moldy sourdough starter is very difficult. It's an indicator that something might be completely off in your starter. Normally the symbiosis of yeast and bacteria does not allow external pathogens such as mold to enter your sourdough starter. The low pH created by the bacteria is a very hostile environment that no other pathogens like. Generally everything below a pH of 4.2 can be considered food safe [17]. This is the concept of pickled foods. And your sourdough bread is essentially pickled bread.

I have seen this happening especially when the sourdough starter is relatively young. Each flour naturally contains mold spores. When beginning a sourdough starter, all the microorganisms start to compete by metabolizing the flour. Mold can sometimes win the race and outcompete the natural wild yeast and bacteria. In that case simply try cultivating your sourdough starter again. If mold reappears again, it might be a very moldy batch of flour. Try a different flour to begin your sourdough starter with.

Mature sourdough starters should not go moldy unless the conditions of the starter change. I have seen mold appearing when the starter is stored in the fridge and the surface dried out. It also sometimes forms on the edges of your starter's container, typically in areas where no active starter microorganisms can reach. Simply try to extract an area of your starter that has no mold. Feed it again with flour and water. After a few feedings, your starter should be back to normal. Take only a tiny bit of starter: 1 g to 2 g are enough. They already contain millions of microorganisms.

Mold favors aerobic conditions. This means that air is required in order for the mold fungus to grow. Another technique that has worked for me was to convert my sourdough starter into a liquid starter. This successfully shifted my starter from acetic acid production to lactic acid production. Acetic acid, similarly to mold, requires oxygen to be produced. After submerging the flour with water, over time the lactic acid bacteria outcompeted the acetic acid bacteria. This is a similar concept to pickled foods. By doing this you are essentially killing all live mold fungi. You might only have some spores left. With each feeding the spores will become fewer and fewer. Furthermore, it seems that lactic acid bacteria produce metabolites that inhibit mold growth [27].

To pickle your starter, simply take a bit of your existing starter (5 g for instance). Then feed the mixture with 20 g of flour and 100 g of water. You have created a starter with a hydration of around 500 %. Shake the mixture vigorously. After a few hours you should start seeing most of the flour near the bottom of your container. After a while most of the oxygen from the bottom mixture is depleted and anaerobic lactic acid bacteria will start to thrive. Take a note of the smell your sourdough starter. If it was previously acetic it will now change to be a lot more dairy. Extract a bit of your mixture the next day by shaking everything first. Take 5 g of the previous mixture, feed again with another 20 g of flour and another 100 g of water. After 2–3 additional feedings your starter should have adapted. When switching back to a hydration of 100 % the mold should have been eliminated. Please note that more tests should be conducted on this topic. It would be nice to really carefully analyze the microorganisms before the pickling and after.

12.1.9 My sourdough starter is too sour

If your sourdough starter is too sour it will cause problems during the fermentation. Your fermentation will have more bacterial activity than yeast activity. This means you will likely create a more tangy loaf which isn't as fluffy as it could be. The goal is to

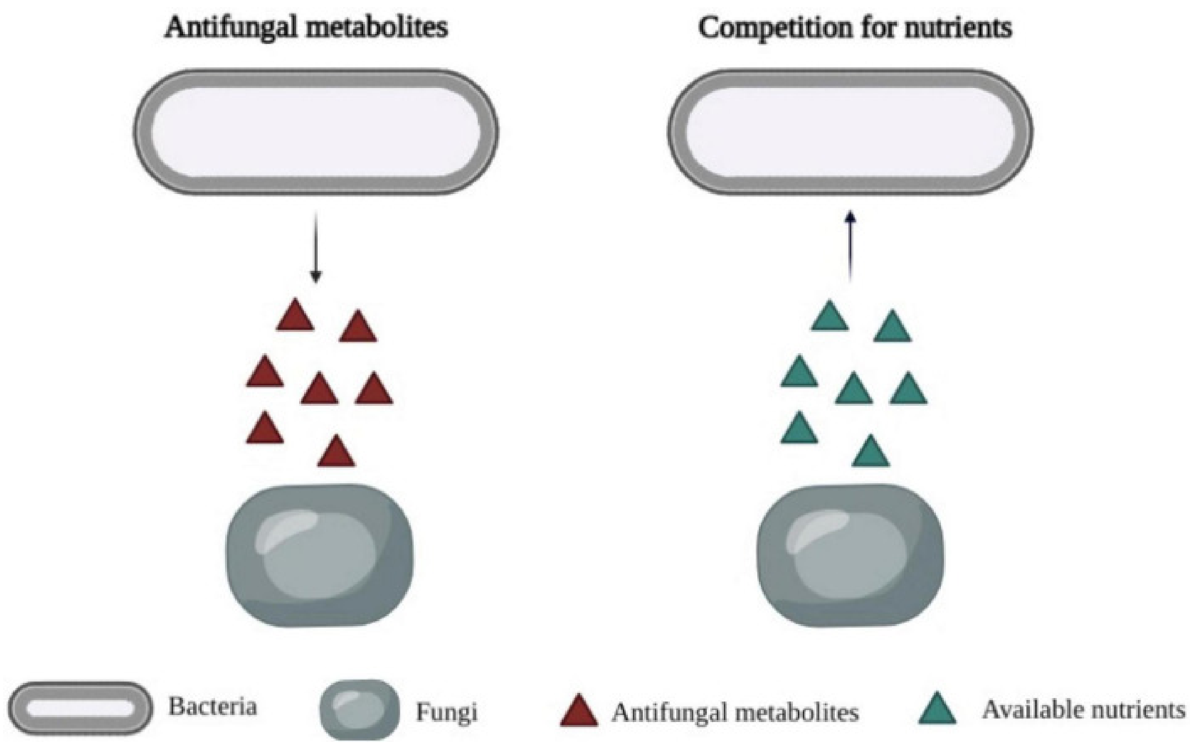


Figure 12.2: The interaction of lactic acid bacteria and mold fungi. In [27], Ce Shi et al. show how bacteria are producing metabolites that inhibit fungus growth.

reach the right balance: Fluffy consistency from the yeast and a great, not-too-strong tang from the bacteria. This depends of course on what you are looking for in terms of taste in your bread. When making rye bread, I prefer to be more on the tangy side for instance. When the described balance is off, the first thing to check is your sourdough starter.

Note the smell of your starter. Does it smell very sour? Taste a bit of your starter too. How sour does it taste? Over time, every starter becomes more and more sour the longer you wait. But sometimes your starter becomes sour too fast. In this case apply daily feedings to your starter. Reduce the amount of old starter that you use to feed. A ratio of 1:5:5 or 1:10:10 can do wonders. In this case you would take 1 part of starter (10 g) and feed it with 50 g of flour and 50 g of water. This way the microorganisms start the fermentation in a greenfield environment. This is similar to the 10 % starter or 20 % starter ratio that you use to make a dough. These days I almost never use a 1:1:1 ratio. This only makes sense when you are initially creating your starter. You want a sour environment so that your microorganisms outcompete potential pathogens. The acidic environment is toxic to most pathogens that you do not want in your starter.

Another approach that can help is to convert your sourdough starter into a stiff starter as described in Section 4.4.

12.1.10 Why does my starter smell like vinegar or acetone?

Your sourdough starter has likely produced a lot of acetic acid. Acetic acid is essential when creating vinegar. Once no additional food is left some of your starter's bacteria will consume ethanol and convert it into acetic acid. Acetic acid has a very pungent smell. When tasting acetic acid, the flavor of your bread is often perceived as quite strong.

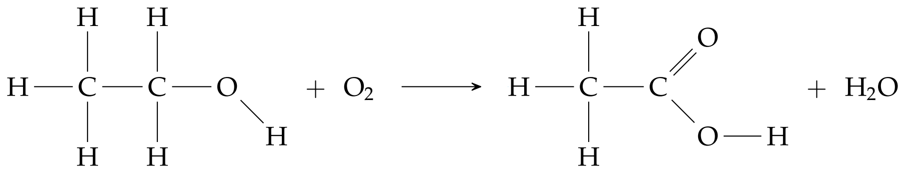


Figure 12.3: Oxygen is required to create acetic acid [28].

This is nothing bad. But if you would like to change the flavor of your final bread, consider converting your sourdough starter into a liquid starter. This will help to prioritize lactic acid-producing bacteria. Your flavor will change to dairy compared to vinegary. You can't go back though. After the conversion your starter will never go back to acetic acid production because you have changed the tides towards primarily lactic acid fermentation. I like to have a separate rye starter. In my experiments rye starters tend to feature many acetic acid bacteria. This starter is excellent when you want to make a very hearty, strong-tasting bread. A pure rye bread tastes excellent when made with such a starter. The flavor when taking a bite is incredible. It nicely plays with soups as well. Just take a bit of this bread and dip it in your soup.

12.1.11 Why does my starter not float after using the float test?

The float test may not reliably determine your starter's readiness for dough inoculation. While it's effective for wheat-based doughs, where ample gas gets trapped in the gluten matrix, it's less reliable for non-wheat doughs. In non- wheat doughs, the gas generated during fermentation tends to escape, causing the starter to likely sink.

For more accurate assessments of your starter's readiness, watch for bubbles at the container's edge and consider its aroma. A mature starter should emit a mildly sour scent without being overly pungent.

12.2 Dough

12.2.1 Should I autolyse my dough?

In 95 % of all cases, an autolysis makes no sense. Instead I recommend that you conduct a fermentolysis. You can read more about the autolysis process in Section 7.6 and more about the topic of fermentolysis in Section 7.7.

The fermentolysis combines all the benefits of the autolysis while eliminating disadvantages such as having to knead the dough multiple times.

The autolysis only makes sense when you might bake a fast-fermenting yeast-based dough with a high yeast inoculation rate. But even in that case you could just lower the amount of yeast to fermentolyse rather than autolyse.

12.2.2 My dough sample (aliquot) doesn't rise. What's wrong?

If you see that your dough rises in size but your aliquot doesn't, chances are that both are fermenting at different speeds. This can often happen when the temperature in your kitchen changes. The aliquot is more susceptible to temperature changes than the main dough. Because the sample is smaller in size, it will heat up or cool down faster.

For this reason, you must use room-temperature water when making your dough. By having the same temperature in both the sample and your dough, you make sure that both ferment at the same rate.

If the temperature in your room changes significantly during the day, your best option is to use a see-through container. Mark the container to properly measure your dough's size increase.

Another option could be to use a more expensive pH meter to measure your dough's acidity buildup. You can read more about different ways of managing bulk fermentation in Section 7.9.

12.2.3 What's a good level of water (hydration) to make a dough?

Especially when starting to make bread, use lower amounts of water. This will greatly simplify the whole process. I recommend using a level of around 60 percent hydration. So for every 100 g of flour use around 60 g of water. This ballpark figure will work for most flours. With this hydration, you can make bread, buns, pizzas, and even baguettes out of the same dough.

With the lower hydration, dough handling becomes easier and you have more yeast fermentation, resulting in lower over-fermentation risk.

12.2.4 My dough completely tears after a long fermentation

Sometimes when touching your dough after a long fermentation it completely tears apart. This could be for two reasons. It might be that the bacteria completely consumed the gluten of your flour. On the other hand, over time your gluten network automatically degrades. This is the protease enzyme converting the gluten network into smaller amino acids the seedling can use as building blocks for its growth. This process starts to happen the moment you mix flour and water. The longer your dough sits, the more gluten is broken down. As the gluten holds the wheat dough together, your dough will ultimately tear.

In the picture 12.4 I experimented with using a starter that has not been fed for 30 days at room temperature. I tried to make a dough directly out of the unfed starter. Typically after a long period without feedings your microbes start to sporulate and go into hibernation mode. This way they can survive for a long period of time without extra feedings. Adding additional food will activate them again. In this case the dough did not ferment fast enough before the protease broke down the gluten. By activating your microbes they will start to reproduce and increase in quantity for as long as there is food available. But this process in my case was not fast enough. After around 24 hours, the whole dough just started to completely tear apart. The whole process was further accelerated by my using whole-wheat flour. Whole-wheat contains more enzymes than white flour.

To fix this, try to make sure that your sourdough starter is lively and active. Simply apply a couple more feedings before making your dough. This way your dough becomes ready to shape before it has completely broken down.

12.3 Bread

12.3.1 My bread stays flat

A flat bread is in most cases related to your gluten network breaking down fully. This is not bad; this means you are eating a fully fermented food. However, from a taste and consistency perspective, it might be that your bread tastes too sour, or is not fluffy anymore. Please also note that you can only make bread with great oven spring when making wheat based doughs. When starting with this hobby I always wondered why my rye breads would turn out so flat. Yes, rye has gluten, but small particles called *pentosans* (arabinoxylan and beta-glucan) [10]. They prevent the dough

Figure 12.4: My dough tearing after 24 hours of no activity.

from developing a gluten network it can with wheat. Your efforts will be in vain, and your dough will stay flat. Only spelt- and wheat-based doughs have the capability of retaining the CO_2 created by the fermentation.

In most cases something is probably off with your sourdough starter. This very often happens when the starter is still relatively young and isn't as capable of fermenting flour. Over time your sourdough starter is going to become better and better. Keep your sourdough starter at room temperature and then apply daily feedings with a 1:5:5 ratio. This would be 1 part old starter, 5 parts flour, 5 parts water. This allows you to achieve a better balance of yeast and bacteria in your sourdough. Even better could be the use of a stiff sourdough starter. The stiff sourdough starter boosts the yeast part of your starter. This allows you to have less bacterial fermentation, resulting in a stronger gluten network toward the end of the fermentation [37]. Please also refer to the Subsection 12.4.2 where I explained more about overfermented doughs. You can also refer to Section 4.4 with more details on making a stiff sourdough starter.

Furthermore, a stronger flour containing more gluten will help you to push the fermentation further. This is because your flour contains more gluten and will take longer to be broken down by your bacteria. Ultimately, if fermented for too long, your dough is also going to be broken down and will become sticky and flat.

To debug whether the excess bacterial fermentation is the issue, simply taste your dough. Does it taste very sour? If yes, that's a good indicator. When working the dough, does it suddenly become very sticky after a few hours? That's a another good indicator. Please also use your nose to note the smell of the dough. It shouldn't be too pungent.

12.3.2 I want more tang in my bread

To achieve more tang in your sourdough bread, you have to ferment your dough for a longer period of time. Over time the bacteria will metabolize most of the ethanol created by the yeast in your dough. The bacteria mostly produce lactic and acetic acid. Lactic acid is chemically more acidic than acetic acid but sometimes not perceived as sour. In most cases a longer fermentation is what you want. You will either need to utilize a loaf pan to make your dough or use a flour that can withstand a long fermentation period. A flour like this is typically called a *strong flour*. Stronger flours tend to be from wheat varieties that have be grown in more sunny conditions. Because of that, stronger flours tend to be more expensive. For freestanding loaves, I recommend using a flour that contains at least 12 % protein. Generally, the more protein, the longer you can ferment your dough.

Another option to achieve a more sour flavor could be to use a starter that produces more acetic acid. Based on my own experience, most of my pure rye starters produced stronger acetic notes. Chemically, the acetic acid isn't as sour, but when tasting it will seem more sour. Make sure to use a starter that is at a hydration of around 100 %. Acetic acid production requires oxygen. A starter that is too liquid tends to favor lactic acid production because the flour is submerged in water. By submerging the dough very little oxygen can pass through the water to the fermenting flour. Because of this, only very little acetic acid can be produced. Over time the acetic acid-producing bacteria will perish from your starter.

Another easier option could be to bake your sourdough twice. I have observed this when shipping bread for my micro bakery. The idea was to bake my bread for around 30 minutes until it's sterilized, let it cool down and then ship it to customers. Once you receive it, you just bake it again for another 20–30 minutes to achieve the desired crust and then you can eat it. Some of the customers reported a very sour tasting

Figure 12.5: A half-baked bread, known as *parbaked*.

bread. After investigating a bit more, it became crystal clear. By baking the bread twice you don't boil off as much acid during the baking process. Water evaporates at around 100 °C (212 °F) while acetic acid boils at 118 °C (244 °F) and lactic acid at 122 °C (252 °F). After baking for 30 minutes at around 230 °C (446 °F) some of the water has started to evaporate, but not all the acid yet. If you were to continue to bake, more and more of the acid would start to evaporate. Now if you were to stop baking after 30 minutes, you would typically have reached a core temperature of around 95 °C (203 °F). Your dough would need to be cooled down again to room temperature. The crust would still be quite pale. Then a couple of hours later, you start to bake your dough again. Your crust would become nice and dark featuring delicious aroma. The aroma is coming from the Maillard reaction. However, the core of your dough still won't exceed the 118 °C required to boil the acid. Overall, your bread will be more sour. The enhanced acidity also helps to prevent pathogens from entering your bread. The bread will be good for a longer period of time. That's why the concept of a delivery bakery works well with tangy sourdough bread. In my own experiments, the bread stayed good for up to a week in a plastic bag. This is much longer than a yeast-based dough that might mold after just a few days.[1]

[1] Some of my first test customers however reported that the bread was overly sour and not pleasant to eat at all. When this happens to you, consider toasting the bread. Toasting will boil off additional acidity.

12.3.3 My bread is too sour

Some people like the bread less sour as well. This is personal preference. To achieve a less sour bread you need to ferment for a shorter period of time. The yeast produces CO_2 and ethanol. Both yeast and bacteria consume the sugars released by the amylase enzyme in your dough. When the sugar is depleted, bacteria starts to consume the leftover ethanol by the yeast. Over time more and more acidity is created, making a more sour loaf.

Another angle at this would be to change the yeast/bacteria ratio of your sourdough. You can start the fermentation with more yeast and less bacteria. This way, for the same given volume increase of your dough, you will have less acidity. A really good trick is to make sure that you feed your starter once per day at room temperature. This way you shift the tides of your starter towards a better yeast fermentation [34].

To shift the tides even further, a real game changer for me has been to create a stiff sourdough starter. The stiff sourdough starter is at a hydration of around 50 %. By doing so your sourdough starter will favor yeast activity a lot more. Your doughs will be more fluffy and less sour for a given volume increase. I tested this by putting balloons over different glass jars. I used the same amount of flour for each of the samples. I tested a regular starter, a liquid starter and a stiff starter. The stiff starter by far created the most CO_2 compared to the other starters. As a consequence, the stiff starter balloon was inflated the most [37]. You can read more about the topic of stiff starters in Section 4.4.

Another unconventional approach could be to add baking powder to your dough. The baking powder neutralizes the lactic acid and will make a much milder dough [38].

12.3.4 My bread flattens out when removing it from the banneton

After removing your dough from the banneton, your dough will always flatten out a bit. That's because over time your gluten network relaxes and can no longer hold the shape. However, during the course of baking, your dough is going to increase in size and inflate again.

If your dough however flattens out completely, it's a sign that you have fermented your dough for too long. Please refer to Subsection 12.4.2 where I explain about overfermented doughs. Your bacteria has consumed most of your gluten network. That's why your dough fully collapses and stays flat during the bake. The CO_2 and evaporating water will diffuse out of the dough. A related symptom is that your dough sticks to the banneton. When I starting baking I combated this with rice flour. It worked for me but it might be a false find. Please refer to Subsection 12.4.2 for more details on why rice flour is not a good idea to manage sticky doughs.

These days I gently rub my dough with a bit of non-rice flour before placing it in the banneton. Now if the dough starts to stick to the banneton while I remove it I resort to a drastic measure. I immediately grease a loaf pan and directly place the dough inside. The loaf pan provides a barrier and the dough can't flatten out as much. The dough won't be as fluffy but it will be super delicious if you love tangy bread.

If you own a pH meter, take a note of your dough's pH before baking. This will allow you to better judge your dough throughout the fermentation process.

12.3.5 My bread flattens out during shaping

Similarly to a dough flattening out after removing it from the banneton, a flattened dough after shaping is also a possible sign of over-fermentation.

When you try to shape the dough, can you easily tear pieces from the dough? If yes, you have definitely overfermented your dough. If not, it might just be a sign that you have not created enough dough strength for your dough. A ciabatta, for instance, is a dough that tends to flatten out a bit after shaping.

If your dough is not able to be shaped at all, use a greased loaf pan to rescue your dough. You can also cut a piece of the dough and use it as the starter for your next dough. Your sourdough dough is essentially just a gigantic starter.

12.3.6 My crust becomes chewy

Depending on which style of bread you are making a thick crackly crust is sometimes desired. The crust of your bread is created during the 2nd stage of the baking process once the steaming source of your oven has been removed. The dark colors are created by the process known as *Maillard reaction* and then followed by another process known as *caramelization*. Each color of crust offers the taster a different aroma.

What happens quite often is that the crust becomes chewy after a day. Sometimes when baking in the tropics with high humidity, the crust only stays in this stage for a few hours. Afterwards the crust becomes chewy. It's no longer as crisp compared to the moment after baking. Your dough still contains moisture. This moisture will start to homogenize in the final bread and partially evaporate. The result is that your crust becomes chewy.

Similarly when storing your bread in a container or in a plastic bag, your crust is going to become chewy. I have no fix for this yet. I typically tend to store my breads in a plastic bag inside of my fridge. This allows the moisture to stay inside of bread. When taking a slice I always toast each slice. This way some of the crispness returns. If you know of a great way, please reach out and I will update this book with your findings.

12.4 Debugging your crumb structure

The crumb structure of your bread provides insights into how well your fermentation process has gone. You can also spot common flaws arising from improper technique. This chapter will provide you with information that you can use to debug your baking process.

12.4.1 Perfect fermentation

Of course the perfect fermentation is debatable and highly subjective. To me the perfect sourdough bread features a crisp crust paired with a fluffy, somewhat open crumb. This is the perfect balance of different consistencies when you take a bite.

Some people are chasers of a very open crumb, meaning you have large pockets of air (alveoli). It's subjective whether that's the style of bread that you like; however, to achieve it you need to ferment your bread dough perfectly. It takes a lot of skill both in terms of mastering fermentation and technique to achieve a crumb structure like that.

Personally, I like a bread like that, just with a slightly less wild crumb. The style of crumb I like is called the *honeycomb crumb*. It's not too open, but just enough open to make the bread very fluffy. To achieve the previously mentioned open crumb, you have to touch your dough as little as possible. The more you interact with your dough, the more you are degassing your dough. Excess touching of the dough results in the dough's alveoli merging together. The crumb will not be as open. That's why achieving such a crumb works best if you only ferment one loaf at a time. Normally, if you have to pre-shape your dough, you will automatically degas your dough a little bit during the rounding process. If you skip this step and directly shape your dough, you will achieve a more open crumb. A good rule of thumb is to not touch your dough for at least 1–2 hours before shaping, to achieve as open a crumb as possible.

Now this is problematic when you want to make multiple loaves at the same time. Pre-shaping is essential as you are required to divide your large bulk dough into smaller chunks. Without the pre-shaping process, you would end up with many non-uniform bread doughs. This technique is also used when making ciabattas. They are typically not shaped. You only cut the bulk dough into smaller pieces, trying to work the dough as little as possible. With pre-shaping you will converge your dough's alveoli into more of a honeycomb structure, as large pockets of air will slightly merge. Similarly to the open crumb structure, you also have to nail the fermentation process perfectly to achieve this crumb. Too long a fermentation will result in gas leaking out of your dough while baking. The honeycombs won't be able to retain the gas. If you ferment for too short a time, there is not enough gas to inflate the structures. To me this is the perfect style of crumb. As someone who appreciates jam, no jam will fall through a slice of this bread compared to an open crumb.

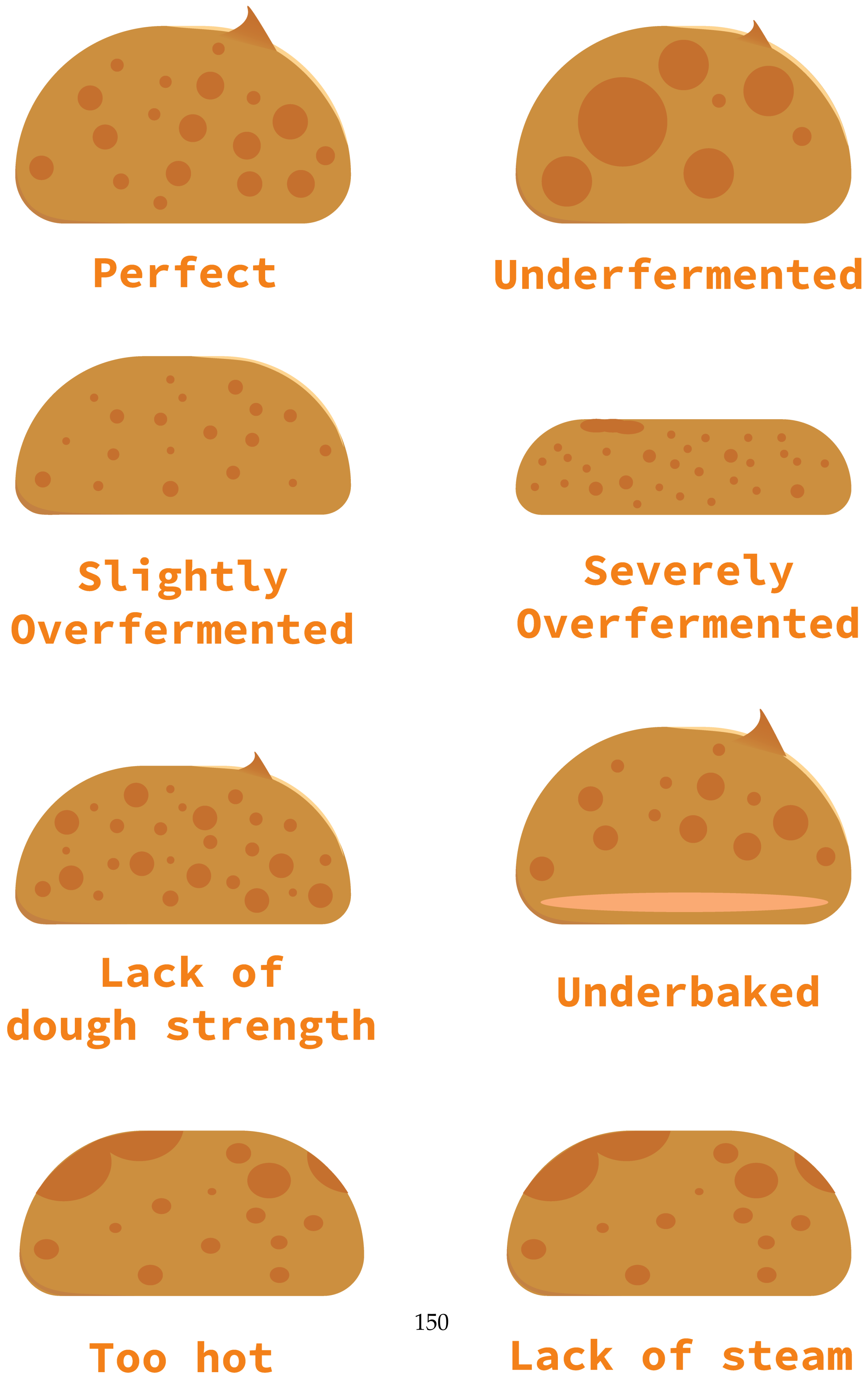


Figure 12.6: A schematic visualization of different crumb structures and their respective causes. The final bread's crumb is a key aspect to identify potential issues related to fermentation or baking technique.

Figure 12.7: The bread has a somewhat open crumb with areas featuring a honeycomb structure.

Figure 12.8: A whole-wheat sourdough with an almost exclusive honeycomb crumb structure.

Figure 12.9: A relatively flat dough that has many tiny pockets of air.

12.4.2 Overfermented

When fermenting your dough for too long, the protease enzyme starts to break down the gluten of your flour. Furthermore, the bacteria consume the gluten in a process called *proteolysis* [30]. Bakers also refer to this process as *gluten rot*. The gluten that normally traps the CO_2 created by the fermentation process of your microorganisms can no longer keep the gas inside of the dough. The gas disperses outward resulting in smaller alveoli in your crumb. The bread itself tends to be very flat in the oven. Bakers often refer to this style of bread as a *pancake*. The oven spring can be compared to bread doughs made out of low-gluten flour like einkorn.

Your bread will feature a lot of acidity, a really strong distinctive tang. From a taste perspective, it might be a little bit too sour. From my own tests with family and friends (n=15–20), I can say that this style of bread is typically appreciated less. However, I personally really like the hearty strong taste. It is excellent in combination with something sweet or a soup. From a consistency perspective, it is no longer as fluffy as it could be. The crumb might also taste a little bit gummy. That's because it has been broken down a lot by the bacteria. Furthermore, this style of bread has a significantly lower amount of gluten [30] and is no longer comparable to raw flour, it's a fully fermented product. You can compare it with a blue cheese that is almost lactose free.

When trying to work with the dough, you will notice that suddenly the dough feels very sticky. You can no longer properly shape and work the dough. When trying to remove the dough from a banneton, the dough flattens out a lot. Furthermore, in many cases your dough might stick to the banneton. When beginning with baking I would use a lot of rice flour in my banneton to dry out the surface of the dough a lot. This way the dough wouldn't stick, despite being overfermented. However as it turns out the stickiness issue has been my lack of understanding the fermentation process. Now I never use rice flour, except when trying to apply decorative scorings. Managing properly fermentation results in a dough that is not sticky.

If you are noticing, during a stretch and fold or during shaping, that your dough is suddenly overly sticky, then the best option is to use a loaf pan. Simply take your dough and toss it into a loaf pan. Wait until the dough mixture has increased in size a bit again and then bake it. You will have a very good-tasting sourdough bread. If it's a bit too sour, you can just bake your dough for a longer period of time to boil away some of the acidity during the baking process. You can also use your dough to set up a new starter and try again tomorrow. Lastly, if you are hungry, you can simply pour some of your dough directly into a heated pan with a bit of oil. It will make delicious sourdough flatbreads.

To fix issues related to over-fermentation, you need to stop the fermentation process earlier. What I like to do is to extract a small fermentation sample from my dough. Depending on the volume increase of this sample, I can mostly judge when my fermentation is finished. Try to start with a 25 % volume increase of your main dough or sample. Depending on how much gluten your flour has, you can ferment for a longer period of time. With a strong flour featuring a 14 % to 15 % protein, you should be able to safely ferment until a 100 % size increase. This however also depends on your sourdough starter's composition of yeast and bacteria. The more bacterial fermentation, the faster your dough structure breaks down. Frequent feedings of your sourdough starter will improve the yeast activity. Furthermore, a stiff sourdough starter might be a good solution too. The enhanced yeast activity will result in a more fluffy dough with less bacterial activity. A better yeast activity also will result in less acidity in your final bread. If you are a chaser of a very strong tangy flavor profile, then a stronger flour with more gluten will help.

When retarding sourdough (cold-proofing in the refrigerator), temperature plays a pivotal role in fermentation rates. As the dough chills in the refrigerator, fermentation decelerates. Starting the retarding process at a warmer temperature means this deceleration takes longer.

For instance, a dough that's ideal after 8 hours of retarding might be ready in merely 4 hours if it began at a higher temperature. Thus, it's crucial to experiment and determine the optimal retarding duration for your specific conditions. Conversely, if the dough starts colder, fermentation halts more rapidly in the refrigerator. In such scenarios, allowing the dough to proof at room temperature briefly before refrigerating can be beneficial.

12.4.3 Underfermented

This defect is also commonly referred to as *underproofed*. However underproofed is not a good term as it only refers to having a short final proofing stage of the bread-making process. If you were to bake your bread after a perfectly-timed bulk fermentation stage, the result will not be underproofed even if you skipped the proofing stage entirely. Proofing will make your dough a bit more extensible and allows your sourdough to inflate the dough a bit more. When faced with an underfermented bread, something

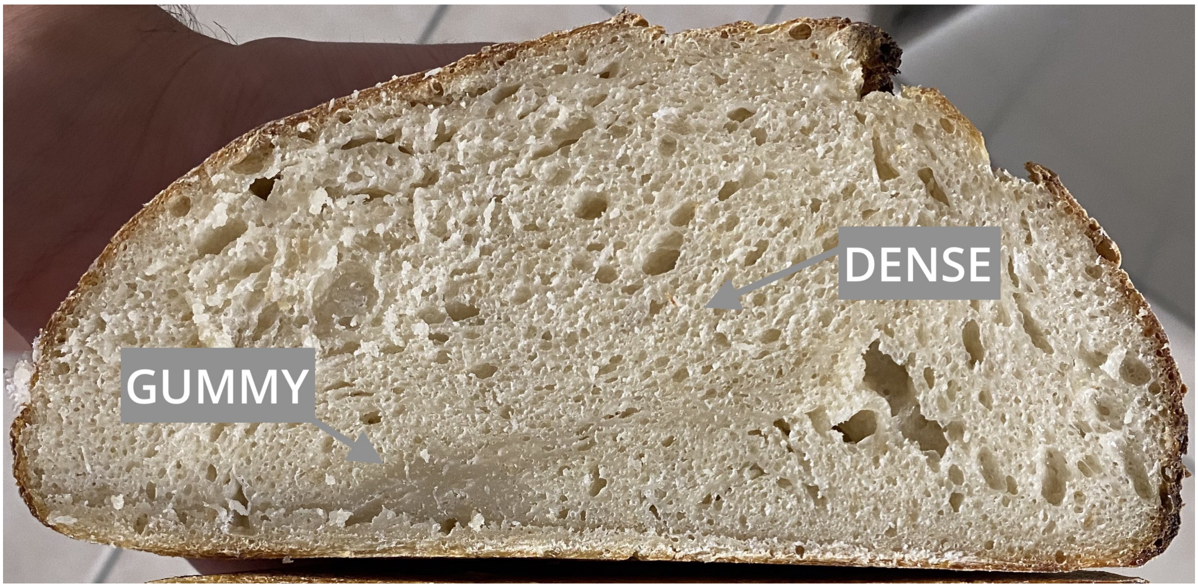


Figure 12.10: A dense dough featuring a gummy, not fully gelatinized area. The picture has been provided by the user wahlfeld from our community Discord server.

went wrong earlier during the bulk fermentation stage, or maybe even before with your sourdough starter.

A typical underfermented dough has very large pockets of air and is partially wet and gummy in some areas of the dough. The large pockets can be compared to making a non-leavened wheat or corn tortilla. As you bake the dough in your pan, the water slowly starts to evaporate. The gas is trapped in the structure of the dough and will create pockets. In case of a tortilla, this is the desired behavior. But when you observe this process in a larger dough, you will create several super alveoli. The water evaporates, and the first alveoli form. Then at some point, the starch starts to gelatinize and becomes solid. This happens first inside of the pockets as the interior heats up faster compared to the rest of the dough. Once all the starch has gelatinized, the alveoli holds their shape and no longer expand. During this process other parts of the bread dough are pushed outwards. That's why an underfermented dough sometimes even features an ear during the baking process. This is also commonly referred to as a *fool's crumb*. You are excited about an ear which can be quite hard to achieve. Plus you might think you finally created some big pockets of air in your crumb. But in reality you fermented for too short a period of time.

In a properly fermented dough, the alveoli help with the heat transfer throughout the dough. From within the many tiny fermentation-induced pockets, the starch gelatinizes. With an underfermented dough, this heat transfer does not properly work. Because of that you sometimes have areas which look like raw dough. Bakers refer to this as a very gummy structure sometimes. Baking your dough for a longer period of time would also properly gelatinize the starch in these areas. However, then other parts of your bread might be baked too long.

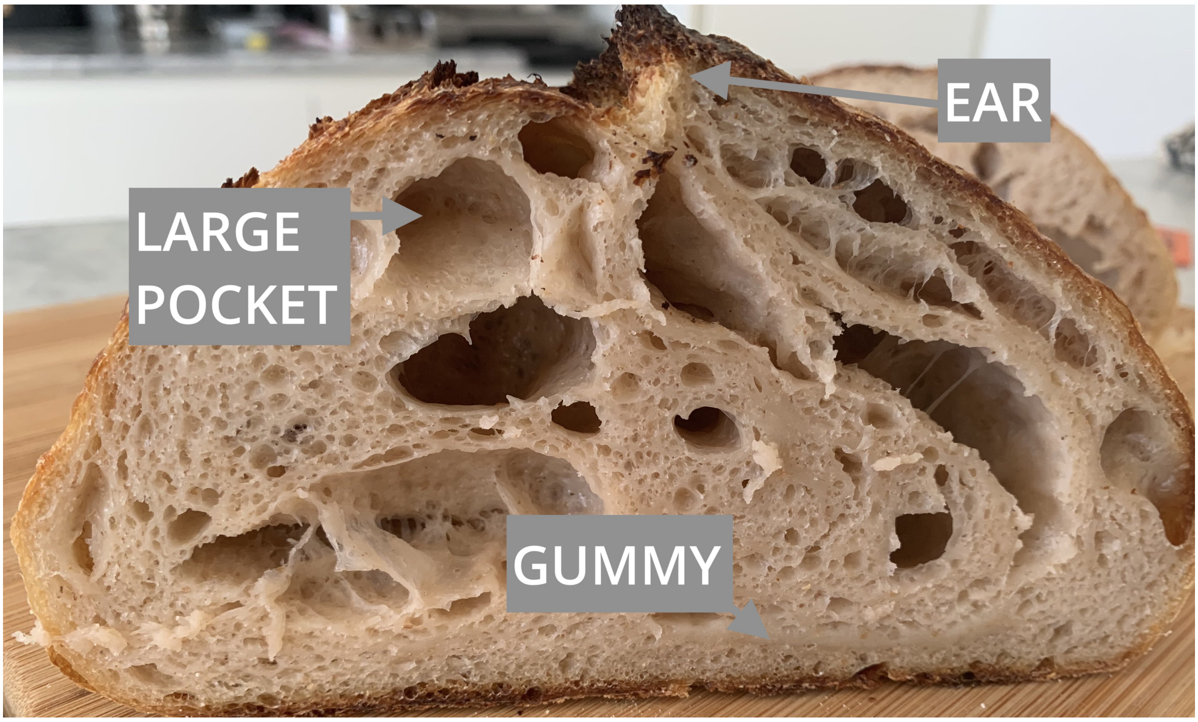


Figure 12.11: A typical example of a fool's crumb featuring an ear and several overly large alveoli. The picture has been provided by Rochelle from our community Discord server.

To fix issues related to under-fermentation, you simply have to ferment your dough for a longer period of time. Now, there is an upper limit to fermentation time as your flour starts to break down the moment it is in contact with water. That's why it might be a good idea to simply speed up your fermentation process. As a rough figure, I try to aim for a bulk fermentation time of around 8–12 hours typically. To achieve that you can try to make your sourdough starter more active. This can be done by feeding your starter daily over several days. Use the same ratio as you would do for your main bread dough. Assuming you use 20 % starter calculated on the flour, use a 1:5:5 ratio to feed your starter. That would be 10 g of existing starter, 50 g of flour, 50 g of water for instance. To boost your yeast activity even more, you can consider making a stiff sourdough starter. The bacteria produces mostly acid. The more acidity is piled up, the less active your yeast is. The stiff sourdough starter enables you to start your dough's fermentation with stronger yeast activity and less bacterial activity.

12.4.4 Not enough dough strength

When a dough flattens out quite a lot during the baking process, the chances are that you did not create enough dough strength. This means your gluten matrix hasn't been developed properly. Your dough is too extensible and flattens out mostly rather than springing upwards in the oven. This can also happen if you proofed your dough for too

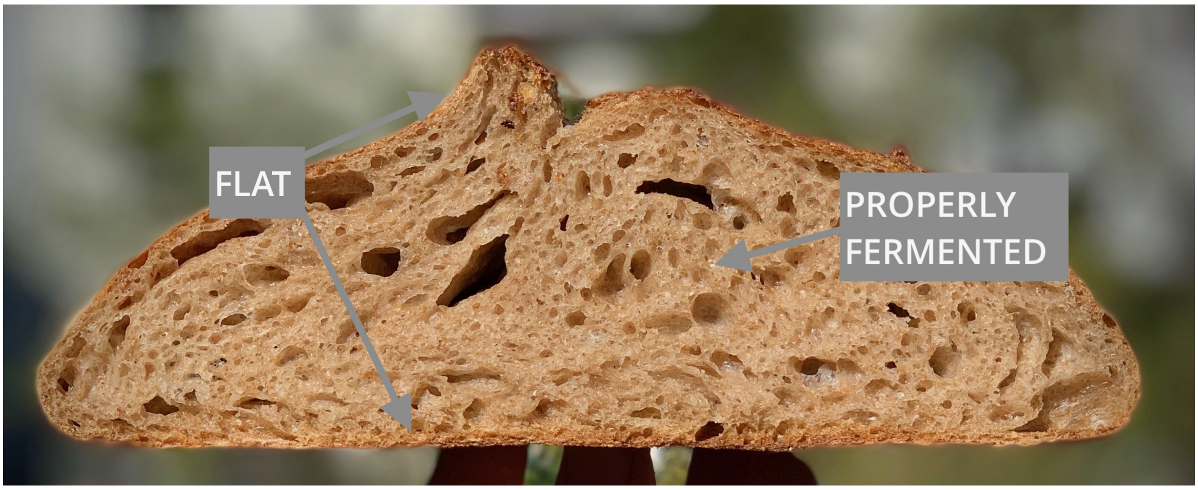


Figure 12.12: A very flat bread without enough dough strength.

long. Over time the gluten relaxes and your dough becomes more and more extensible. You can observe the gluten relaxing behavior too when making a pizza pie. Directly after shaping your dough balls, it's very hard to shape the pizza pie. If you wait for 30–90 minutes stretching the dough becomes a lot easier.

The easiest way to fix this is probably to knead your dough more at the start. To simplify things consider using less water for your flour too. This will result in a more elastic dough right away. This concept is commonly used for no-knead style sourdough. Alternatively, you can also perform more stretch and folds during the bulk fermentation process. Each stretch and fold will help to strengthen the gluten matrix and make a more elastic dough. The last option to fix a dough with too little dough strength is to shape your dough tighter.

12.4.5 Baked too hot

This is a common mistake that has happened to me a lot. When you bake your dough at too high a temperature, you constrain your dough's expansion. The starch gelatinizes and becomes more and more solid. At around 140 °C (284 °F) the Maillard reaction starts to completely thicken your bread dough's crust. This is similar to baking your bread dough without steam. As the internal dough's temperature heats up, more and more water evaporates, gas expands and the dough is being pushed upwards. Once the dough reaches the crust, it can no longer expand. The alveoli merge into larger structures close to the surface of the dough. By baking too hot, you are not achieving the ear which adds extra flavor. Furthermore, by restricting it's expansion, the crumb will not be as fluffy as it could be.

If you have an extensible dough with high hydration, baking too cold will result in the dough flattening out quite a lot. The gelatinization of the starch is essential for the

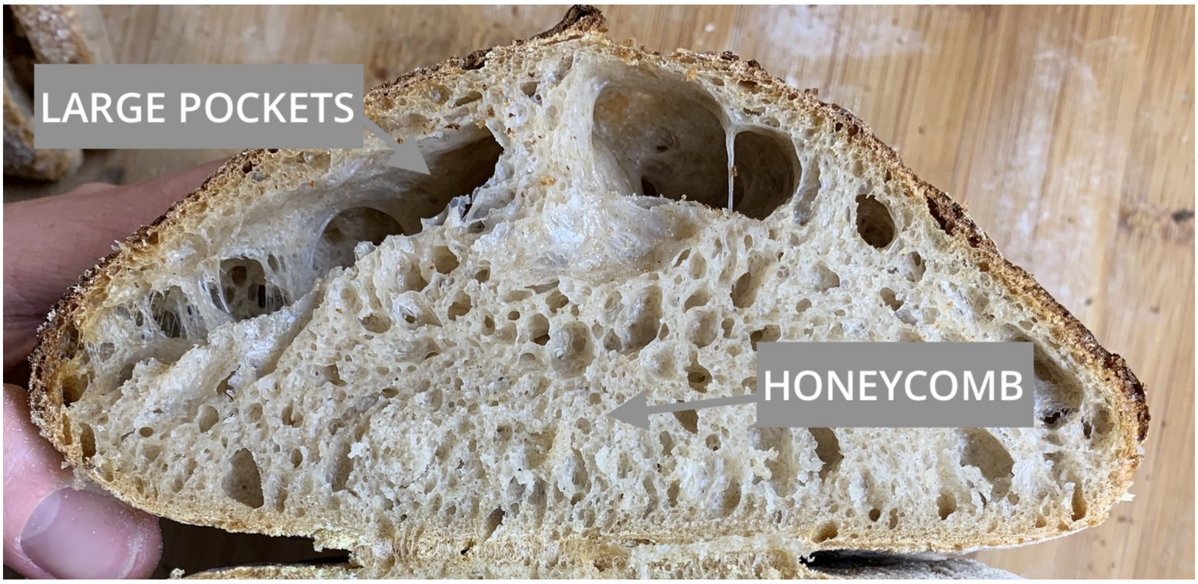


Figure 12.13: A bread with very large alveoli close to the crust.

dough to hold its structure. After conducting several experiments, it seems that my sweet spot for maximum oven spring seems to be at around 230 °C (446 °F). Test the temperature of your oven, because in several cases the displayed temperature might not match the actual temperature of your oven [35]. Make sure to turn off the fan of your oven. Most home ovens are designed to vent the steam as fast as possible. If you can not turn the fan off, consider using a Dutch oven.

12.4.6 Baked with too little steam

Similar to baking too hot, when baking without enough steam, your dough's crust forms too quickly. It's hard to spot the difference between the two mistakes. I typically first ask about the temperature and then about the steaming technique to determine what might be wrong with the baking process. Too little steam can typically be spotted by having a thick crust around all around your dough paired with large alveoli towards the edges.

The steam essentially prevents the Maillard reaction from happening too quickly on your crust. That's why steaming during the first stages of the bake is so important. The steam keeps the temperature of your crust close to around 100 °C (212 °F). Achieving steam can be done by using a Dutch oven, an inverted tray and/or a bowl of boiling water. You might also have an oven with a built-in steam functionality. All the methods work, it depends on what you have at hand. My default go-to method is an inverted tray on top of my dough, paired with a bowl full of boiling water towards the bottom of the oven.

Figure 12.14: One of my earlier breads that I baked at a friend's place where I couldn't steam the dough properly.

Now there can also be too much steam. For this I tested using a Dutch oven paired with large ice cubes to provide additional steam. The temperature of my dough's surface would directly jump close to 100°C. The steam contains more energy and thus through convection can heat up the surface of your dough faster. I tested this by putting an apple inside a Dutch oven and measuring its surface temperature using a barbecue thermometer. I then changed the steaming methods to plot how quickly the temperature close to the surface changes. I tested an ice cube inside of a preheated Dutch oven, a plain preheated Dutch oven, a preheated Dutch oven with spritzes of water on the apple's surface and a non-preheated Dutch oven where I would only preheat the bottom part. The experiment then showed that the ice-cube method would heat up the surface of the apple a lot quicker. When replicating this with a bread dough, I would achieve less oven spring.

Generally though, achieving too much steam is relatively challenging. I could only make this mistake when using a Dutch oven as the steaming method paired with relatively large ice cubes. After talking with other bakers using the same Dutch oven, it seems that my ice cubes (around 80 g) were 4 times as heavy as the ones other bakers would use (20 g).

Figure 12.15: An apple with 2 probes to measure ambient and surface temperatures of several steaming techniques in a Dutch oven.

12.5 Misc

12.5.1 Baking in the tropics

Depending on the temperature, your fermentation speed adapts. In a warmer environment, everything is faster. In a colder environment, everything is slower.

This includes the speed at which your sourdough ferments the dough but also the speed of enzymatic reactions. The amylase and protease enzymes work faster, making more sugars available and degrading the gluten proteins.

At around 22 °C (72 °F) in my kitchen my bulk fermentation is ready after around 10 hours. I use around 20 % of sourdough starter based on the flour. In summertime the temperatures in my kitchen sometimes increase to 25 °C (77 °F). In that case I reduce the sourdough starter to around 10 %.

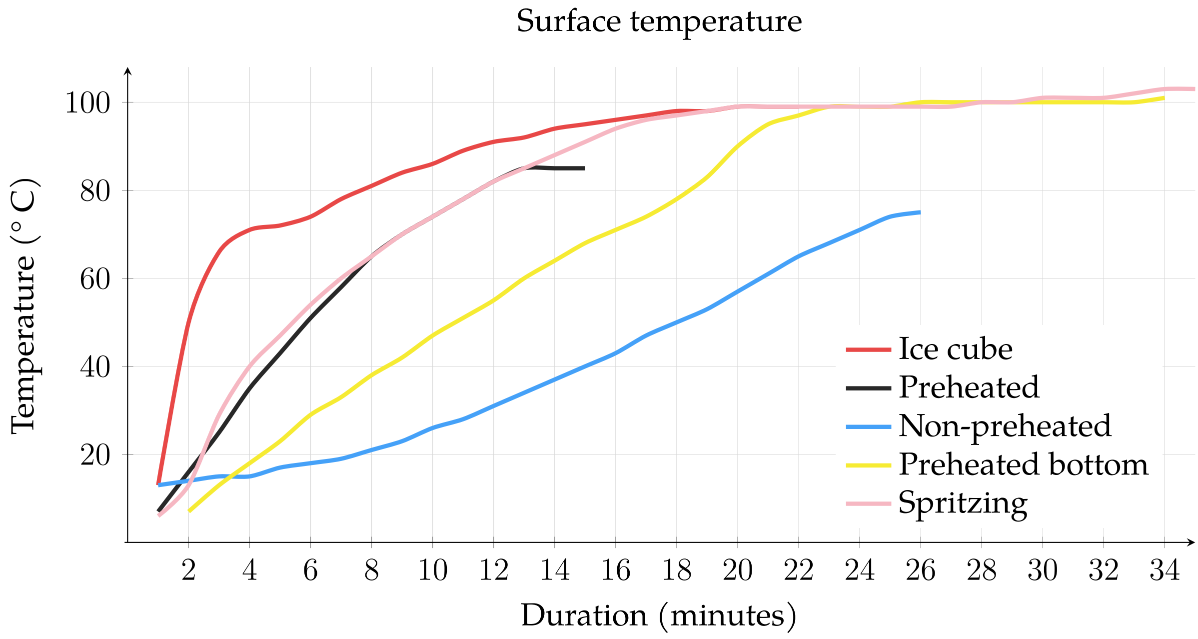


Figure 12.16: A chart showing how the temperature of the apple's surface changes with different steaming techniques.

If I didn't do that, my fermentation would be done after around 4–7 hours. The problem is that the dough is quite unstable when fermenting at this high speed. This means that you easily run into issues of over-fermentation. Finding the perfect sweet spot between fermenting enough and not too much becomes much harder. Normally you might have a time window of 1 hour. But at the rapid speed it might be reduced to a time window of 20 minutes. Now at 30 °C (86 °F), everything moves much faster. Your bulk fermentation might be complete in 2–4 hours when using 10 % to 20 % starter. Proofing your dough in the fridge becomes almost impossible. As your dough cools down in the fridge the fermentation also slows down. However cooling the dough down from 30 °C to 4 °C to 6 °C in your fridge takes much longer. Your dough is much more active compared to a dough that starts at a temperature of 20 °C to 25 °C. You might end up overproofing your dough if you leave it overnight in the fridge.

That's why I recommend that you reduce the amount of starter that you use in the tropics to around 1 % to 5 % based on the flour. This will slow down the fermentation process significantly and provides you a bigger window of time. Try to aim for an overall bulk fermentation of at least 8–10 hours. Reduce the amount of starter to get there.

When making dough, try to use the same water temperature as your ambient temperature. Assuming that the temperature will climb to 30 °C try to start your dough with 30 °C water. This means that you can carefully rely on a small fermentation sample (aliquot jar) that visualizes your fermentation progress. To read more about this

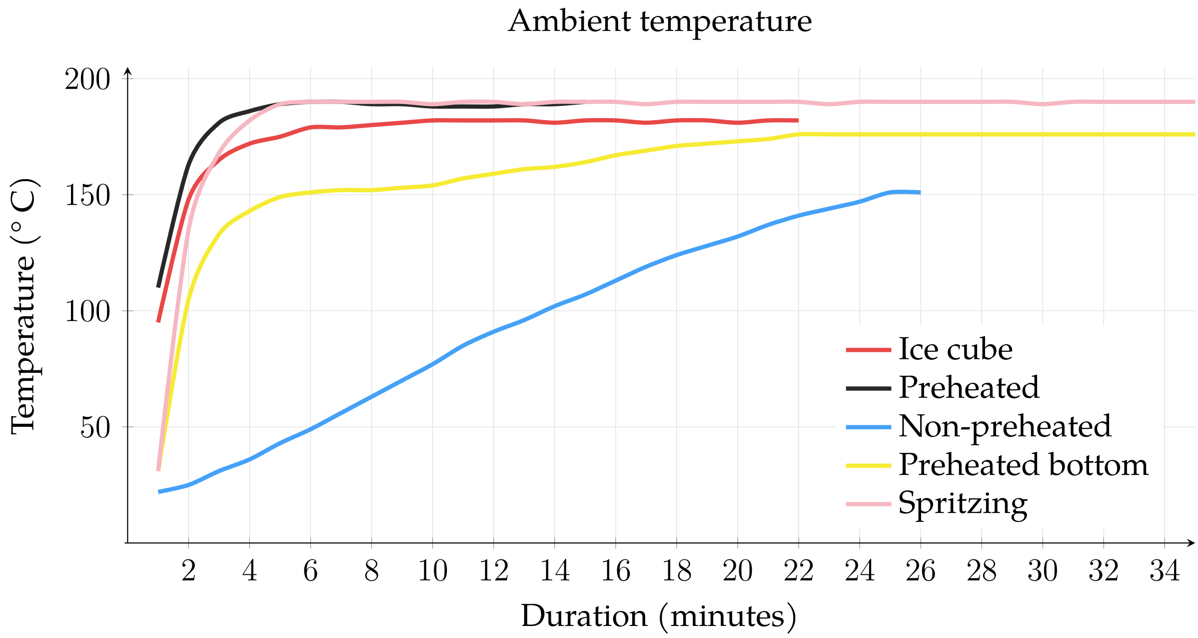


Figure 12.17: This figure shows how the ambient temperatures inside of the Dutch oven change depending on the steaming technique that is used.

technique refer to Section 7.9.

The sample only works reliably if your dough temperature is equal to your ambient temperature. Else the sample heats up or cools down faster. So tread carefully when using the sample in this case. It's always better to stop the fermentation a little too early rather than too late. Stretch and folds during the bulk fermentation will help you to develop a better feel for the dough. An expensive but possibly useful tool could be a pH meter that allows you to perfectly measure how much acidity has been created by the lactic and acetic acid bacteria. In this case measure the pH repeatedly and figure out a value that works for your sourdough. In my case I tend to end bulk fermentation at a pH of around 4.1. Please don't just follow my pH value; it's very individual. Keep measuring with different doughs to find out a value that works for you.

12.5.2 My flour has low gluten content — what should I do?

You can always mix in a little bit of vital wheat gluten. Vital wheat gluten is concentrated extracted gluten from wheat flour.

I recommend that you add around 5 g of wheat gluten for every 100 g of flour that you are using.

12.5.3 What's the best stage to incorporate inclusions (seeds) into the dough?

You can include seeds directly at the start when mixing the dough. If you use whole seeds such as wheat or rye kernels, soak them in water overnight and then rinse them before adding them to the dough. This makes sure that they are not crunchy and are soft enough when eating the bread. If you forgot to soak them you can cook the seeds for 10 minutes in hot water. Rinse them with cold water before adding them to your dough.

If you want to sweeten the dough, your best option is to add sugar during the shaping stage. Sugar added too early in the process typically gets fermented until none of it remains. Adjust your shaping technique a little bit and spread your sugar mixture over a flattened-out dough. You can then roll the dough together, incorporating layers of sugar.

Glossary

This glossary provides definitions and explanations for terms frequently used in bread making. Understanding these terms is essential for both novice and experienced bakers aiming to master the art and science of bread making. The glossary is arranged alphabetically for easy reference.

Acetic Acid
A type of organic acid produced by hetero fermentative lactic acid bacteria and acetic acid bacteria during fermentation. It gives sourdough bread its characteristic tangy flavor and helps to preserve the bread by lowering its pH. The flavor of acetic acid has a more vinegary profile.

Aliquot jar
A small piece of dough extracted after creating initial dough strength. The aliquot jar is used to monitor the dough's fermentation progress. It's important to ensure the dough's water temperature in the aliquot matches your room temperature for accurate readings. Be mindful that the aliquot jar may not be as effective if there are significant temperature fluctuations in your kitchen. This is because the small dough sample in the aliquot can heat up or cool down faster than the main dough mass, potentially impairing its ability to accurately monitor fermentation. It's crucial to use a cylindrical-shaped aliquot container to properly judge the dough's size increase.

All Purpose Flour
A general flour that's balanced to make breads and also cakes. In Germany this is type 550.

Alpha-amylase
A type of amylase that breaks down starch molecules into shorter fragments, producing maltose and some glucose.

Alveograph
A device used primarily in the evaluation of wheat flour's baking quality. The alveograph assesses the dough's rheological properties, particularly its extensibility and resistance to extension, by inflating a piece of dough like a balloon until it bursts. The resulting chart, or *alveogram*, displays a curve that represents the balance between the dough's elasticity and extensibility. Specific parameters derived from the curve, such

as the P (pressure required to inflate the dough) and L (extensibility of the dough), provide invaluable insights to bakers and millers regarding the flour's potential performance in bread-making. By analyzing the alveogram, professionals can make informed decisions about the suitability of a flour for certain baking applications, as well as potential blending needs with other flours.

Alveoli
(singular Alveolus) The little pockets that form the crumb, formed by the gluten matrix trapping carbon dioxide.

Amylase
An enzyme that breaks down starches into simpler sugars, facilitating the fermentation process in beer and bread making. When making beer the temperature of the brew is kept for extended periods at certain temperatures to ensure that most starches are broken down to sugars. These sugars are then consumed by the microbes during the fermentation process.

Autolyse
A process where flour and water are mixed and then left to rest before adding other ingredients. This activates enzymes such as amylase and protease. By doing so the bulk fermentation time is shortened and the final loaf will have better properties. The browning of the loaf becomes better and the crumb fluffier. An autolyse is recommended when using a high percentage of starter to inoculate the dough ($> 20\,\%$). An alternative easier approach can be the fermentolyse.

Bacteria
Unicellular microorganisms that exist in diverse forms and habitats. They play crucial roles in various natural processes, especially in food preparation like sourdough fermentation. Lactic and acetic acid bacteria, in particular, are pivotal in the sourdough process, contributing to its distinct taste and texture. Some bacteria are beneficial, aiding in digestion or producing vitamins, while others can be harmful and cause diseases.

Baker's Math
Baker's math is a ratio based system of sharing recipes, making them easily scalable. It's based on the total weight of the flour in a formula, where each ingredients weight is divided by the flours weight to give a percentage. For 500 g of flour you could be using 60 % of water (300 g), 10 % of starter (50 g) and 2 % of salt (10 g).

Baker's percentage
See Baker's math.

Baking
The final, transformative step in bread making wherein dough is exposed to high temperatures, causing a series of chemical and physical reactions that result in a finished loaf of bread. During the baking stage:

1. *Yeast Activity & Oven Spring:* In the initial phase of baking, the temperature inside the dough rises, increasing yeast activity. This results in rapid carbon dioxide production, leading to what bakers refer to as *oven spring*, or the rapid rise of the loaf.
2. *Protein Coagulation:* As the temperature continues to climb, the proteins in the dough, primarily gluten, begin to coagulate or set, which gives the bread its structure.
3. *Starch Gelatinization:* Starches absorb water and swell, eventually gelatinizing. This process contributes to the crumb structure of the bread.
4. *Caramelization & Maillard Reaction:* The crust of the bread browns due to two primary reactions: caramelization of sugars and the Maillard reaction between amino acids and reducing sugars. This not only affects the appearance but also imparts a distinctive flavor and aroma to the bread.
5. *Evaporation of Acids:* Some acids produced during fermentation evaporate at certain temperatures during baking. This evaporation can influence the final flavor profile of the bread, making it less tangy than the unbaked dough. By extending the baking time the acids become less concentrated and the dough can lose some of its tang.
6. *Moisture Evaporation:* Water in the dough turns to steam and begins to evaporate. The steam contributes to the oven spring and also helps in gelatinizing the starches.
7. *Crust Formation:* The outer layer of the dough dries out and hardens to form a crust, which acts as a protective barrier, keeping the inner crumb moist.

Banneton
A wicker basket used to shape and support dough during its final proof. The bannetons are typically made out of rattan or wood pulp. An alternative DIY solution is to use a bowl with a kitchen towel inside. While resting inside of the banneton the dough's surface dries out and becomes easier to score before baking.

Bassinage method
A bread making technique involving the staged addition of water to the dough. Initially, the dough is mixed to a lower hydration level, allowing gluten bonds to form more effectively. Once these gluten structures are established, additional water is gradually incorporated through further kneading. This method enhances the dough's extensibility, especially beneficial when working with lower-gluten flours. By employing the bassinage method, bakers can achieve a dough that is both strong and extensible.

Bench Rest
A short resting period given to the dough after preshaping allowing the gluten to relax a little bit and making shaping easier. Most people bench rest for 10 minutes up to an hour. The bench rest becomes especially important when making pizza doughs. Without an extended bench rest the dough is too elastic and can not be shaped.

Beta-amylase
An enzyme that further breaks down the starch fragments produced by alpha-amylase into maltose.

Bread Flour
A flour that is perfect for sourdough bread making. It features a higher amount of gluten and can thus ferment for a longer period of time.

Brühstück
A German baking technique similar to a scald. It translates as *boil piece*. Hot or boiling water is poured over whole grain flour or crushed grains, then cooled and mixed with the main dough. This process helps in moisture retention and can enhance the flavor and texture of the final bread. Also see *scald*.

Bulk Fermentation
The initial rising period after mixing all the ingredients. The dough is typically allowed to rise until it increases to a certain volume. The volume of increase depends on the flour that is used. When baking with wheat flour the gluten amount of the flour is the deciding factor. The more gluten your flour has (protein) the longer you can bulk ferment. A longer bulk fermentation improves the flavor and texture of the final bread. It becomes tangier and fluffier. You can aim for a 25 % size increase of your dough and then slowly increase this to find your flour's sweet spot. This is highly dependant from flour to flour. When using low gluten flour like rye you need to be careful as the longer fermentation can create a too sticky dough which collapses and does not hold its shape anymore.

Cake Flour
Cake flour is a light, finely milled flour with a lower protein content than all-purpose flour. It's ideal for tender baked goods like cakes, cookies, and pastries.

Coil fold
A special stretch and folding technique. The coil fold is very gentle on the dough and is thus excellent throughout the bulk fermentation. By applying the coil fold the dough strength is improved by minimizing damage to the dough structure.

Crumb
The inner texture of the bread, which is characterized by the size, shape, and distribution of the holes (or *alveoli*). It's what's inside once you slice a loaf of bread open. A *tight crumb* refers to bread with small, evenly distributed holes, while an *open crumb* has larger, more irregular holes.

Diastatic Malt
Malted grain that has been dried and then ground into a powder. This malt contains enzymes that can break down starches into sugars, which can be beneficial in the fermentation process for bread. When added to dough, it can improve the bread's flavor, color, and shelf life.

Discard
The portion of sourdough starter that is removed and not fed when maintaining the starter. This is often done to prevent the starter from becoming too large and unmanageable. Discard can be used in various recipes or thrown away.

Dividing
The process of breaking the dough mass into smaller pieces, typically to shape into individual loaves or portions.

Dough Hydration
Expressed as a percentage, it's the amount of water in a dough relative to the amount of flour. A higher hydration dough will be wetter and stickier, while a lower hydration dough will be firmer. For example, a dough with 500 g of flour and 375 g of water has a hydration of 75 %

Dough Strength
Refers to the dough's resilience, elasticity, and structure. A strong dough can be stretched without tearing and holds its shape well. This is largely influenced by the flour's protein content and the development of the gluten network.

Dutch Oven
A heavy-duty pot with a tight-fitting lid, often made of cast iron. It's used in baking to trap steam during the initial phase of baking, helping to create a crusty exterior on bread.

Elasticity
A property of dough that describes its ability to return to its original shape after being stretched or deformed. It's influenced by the flour's protein content and the development of the gluten network.

Extensibility
Refers to the dough's ability to be stretched or extended without tearing. It's the opposite of elasticity and is desirable in certain types of breads, like ciabatta, that have a more open crumb structure.

Feed
The act of adding fresh flour and water to maintain a sourdough starter. Regular feeding keeps the starter active and healthy.

Fermentation
The metabolic process by which microorganisms such as yeast and bacteria convert carbohydrates (like sugars) into alcohol or acids. In bread making, this produces carbon dioxide which causes the dough to rise.

Fermentolyse
Using a small amount of starter to slow fermentation. It's a method where fermentation and autolyse are combined. Typically around 10 % of starter is used for the fermentolyse.

The flour, water and starter are mixed together. By adding the starter early the dough becomes more extensible and easier to handle.

Finger poke test
The finger poke test is a simple yet effective way to check if your sourdough bread is ready to bake. After the final rise, lightly flour your finger and gently press about half an inch into the dough. If the dough springs back slowly and leaves a slight indentation, it's perfect and ready for the oven. If it springs back quickly, it needs more time to rise. However, if the dough collapses or doesn't spring back at all, it may be over fermented.

Float test
The float test is a technique for assessing the readiness of a sourdough starter. To perform this test, take a small sample of your starter and gently place it in a glass of water. The outcome of this test can provide insights into your starter's fermentation stage.

> *Positive result:* If your starter effortlessly floats on the surface of the water, it's a clear indication that it has reached its peak of fermentation and is ready to be used as a leavening agent in your dough. This buoyancy is a result of the carbon dioxide gas produced during the active fermentation process.
>
> *Negative result:* Conversely, if your starter sinks to the bottom of the glass, it suggests that it's not quite ready yet. This indicates that the fermentation process has not progressed sufficiently for optimal leavening power.

It's worth noting that while the float test is a reliable indicator for wheat-based sourdough starters, it may not be as effective for non-wheat starters. This is because the gas generated during fermentation in non-wheat starters tends to escape more readily, making it less buoyant. For non-wheat starters, a more accurate approach involves observing the presence of bubbles in your starter jar and assessing its aroma. A mature starter should emit a mildly sour, but not overly pungent, scent.

Fool's Crumb
A term used to describe a crumb structure that has several large pockets or holes, rather than an even distribution of smaller holes. This isn't necessarily a desired feature, as it can indicate uneven fermentation or improper shaping techniques.

Gluten
A protein complex formed from gliadin and glutenin, found in wheat and some other grains. It provides elasticity and strength to the dough when properly aligned and developed. During the course of the bulk fermentation much of the gluten is degraded by the protease enzyme and lactic acid bacteria.

Homogenizing
The act of creating a consistent and uniform mixture. For flours like einkorn and rye, where gluten alignment isn't the main goal, kneading ensures that the dough achieves this homogeneous consistency.

Hooch
A liquid layer that sometimes forms on top of a sourdough starter. It's an indication that the starter is hungry and needs feeding. It acts as a barrier shield and prevents the starter from catching mold. It can be mixed right back into the starter or extracted to make hot sauces.

Kneading
The manual or mechanical process of working dough to develop gluten in wheat and spelt-based breads, or to homogenize the dough mass in flours like einkorn or rye.

Kochstück
When making a Kochstück, the flour or grains are heated together with the fluid. The mixture needs to be stirred while heating up to prevent clumping and burning it.

Lactic Acid
Another organic acid produced by lactic acid bacteria during fermentation. It imparts a mild tangy yogurty flavor to sourdough bread and, along with acetic acid, contributes to the bread's overall acidity.

Levain
See Sourdough starter.

Maillard Reaction
The Maillard reaction is one of the causes of food browning during cooking. The reaction occurs between reducing sugars and amino acids, and depending on the initial reactants and cooking conditions can produce a wide variety of end products with different tastes and aromas. Maillard reactions occur readily above 150 °C, although will still occur much more slowly below that temperature. Optimal reaction rate occurs between pH 6.0 to pH 8.0, although it favors alkaline conditions.

Maltose
A sugar produced from the enzymatic breakdown of starch by amylases. It's a primary food source for yeast during fermentation.

Non-diastatic Malt
Malted grain that has been dried at higher temperatures, deactivating its enzymes. It's used primarily for flavor and color in bread making. Amylase and protease become degraded at temperatures higher than 50°C.

Oven Spring
The rapid rise of the dough in the oven during the early stages of baking due to the expansion of trapped gases and water.

Over Fermenting
A common problem when making wheat or spelt doughs. When the dough is fermented for too long most of the gluten in the dough is broken down. The resulting dough is very sticky. The final bread will be very flat and lose some of its typical texture. The crumb structure features many tiny pockets of air. A lot of the trapped gasses can

diffuse out of the dough during baking. If you notice this during bulk fermentation it is advised to place the loaf inside of a loaf pan and then bake it after a 30 to 60 minute rest.

Over Proofing
The same as over fermenting, however happening during the proofing stage.

pH
A measure of the acidity or alkalinity of a solution. The pH scale ranges from 0 to 14, where a pH value of 7 is neutral. Solutions with a pH value below 7 are acidic, while those with a pH above 7 are alkaline or basic. Fermented foods with a pH below 4.2 are generally considered foodsafe. A pH meter can be used to monitor your sourdough bread's fermentation progress.

P/L Value
A critical parameter derived from the alveograph test, the P/L value represents the ratio of the dough's tenacity (P) to its extensibility (L). Specifically:

> *P* (*Pressure*) refers to the pressure required to inflate the dough during the alveograph test. It indicates the dough's resistance to deformation or its strength.
>
> *L* (*Length*) represents the extensibility of the dough, or how far it can be stretched before tearing.

The P/L ratio provides insights into the balance between the dough's elasticity and extensibility:

> *Low P/L Value* indicates a dough that is more extensible than resistant. This means the dough can be stretched easily, making it suitable for certain products like pizza or ciabatta.
>
> *High P/L Value* suggests a dough that has more strength than extensibility. Such a dough is more resistant to deformation, which can be preferable for products that require good volume and structure, like certain types of bread.

The P/L value helps bakers and millers determine the suitability of a flour for specific baking applications. Adjustments in flour blends or baking processes might be made based on this ratio to achieve desired bread characteristics.

Preferment
A mixture of a proportion of the doughs ingredients which is allowed to ferment before being added to the final bread dough. These can include sourdough, poolish, biga, pâte fermentée, or a general sponge.

Preshaping
When dividing your large dough mass into smaller portions you end up having non-uniform pieces of dough. This makes shaping much harder because the resulting shaped dough will not be uniform. For this reason bakers drag the tiny dough pieces over the surface of the counter to create more uniform looking dough balls.

Proof
The final rise of the shaped dough before baking.

Protease
An enzyme that breaks down proteins, including gluten, into smaller peptide chains and amino acids. In the context of bread making, protease activity can both benefit and challenge bakers. Moderate protease activity can make dough more extensible, which can be helpful in some bread-making processes. However, excessive protease activity can weaken the gluten network, leading to doughs that are slack, sticky, and challenging to handle, and may result in breads with poor volume and structure. Factors such as fermentation time, dough temperature, and the source of the flour can influence protease activity in bread doughs. In sourdoughs, longer fermentation times, particularly at warmer temperatures, can lead to higher protease activity, as the acidic conditions activate cereal proteases. Flour from sprouted grains or malted grains can have higher protease activity due to the sprouting or malting process. Understanding and controlling protease activity is crucial in achieving desired bread quality and handling characteristics.

Pullman Loaf
A type of bread loaf characterized by its perfectly rectangular shape and soft, fine crumb. It is baked in a special lidded pan called a Pullman pan or pain de mie pan. The lid ensures that the bread rises in a perfectly straight shape, without the domed top characteristic of other bread loaves. Pullman loaves are often sliced very thin and are popular for making sandwiches.

Retarding
The process of slowing down fermentation during the proofing stage by placing the dough in a colder environment, typically a refrigerator. This aids bakers in scheduling, allowing them to have more control over when to bake their breads, especially in large-scale bakeries where timing is essential to serve freshly baked bread to early morning customers. While scheduling is the main reason, some bakers also assert that retarding can enhance the bread's overall flavor profile. Also known as fridge-proofing.

Rye
A type of grain used in baking. Due to its low gluten content, breads made solely from rye flour tend to be dense. However, rye has a unique flavor and many health benefits, so it's often combined with wheat flour in baking. Pure rye breads are typically made with a sourdough process to help the dough rise.

Scald
A method where boiling water is poured over flour, grains, or other ingredients and then allowed to cool. In baking, this process can gelatinize the starches in the flour or grains, resulting in a dough that retains moisture better, provides a softer crumb, and potentially extends the bread's shelf life. Additionally, scalding can help inactivate certain enzymes which can be detrimental to the dough's quality. The scalding technique can also enhance the overall flavor and aroma of the bread, bringing out more

pronounced grainy notes and reducing bitterness sometimes found in certain whole grains.

Scoring
Cutting the surface of the bread dough before it's baked. This allows the dough to expand freely in the oven, preventing it from bursting in unpredictable ways. It also provides a controlled aesthetic to the finished loaf.

Sift
To pass flour or another dry ingredient through a sieve to remove lumps and aerate it.

Soaker
A mixture of grains or seeds with water that is left to soak overnight (or for a specified amount of time) before being incorporated into bread dough. This helps to soften and hydrate the grains or seeds (sesame, pumpkin, etc.), making them easier to integrate into the dough and providing a moister crumb in the finished bread.

Sponge
A type of preferment, a sponge is a wet mixture of flour, water, and yeast that is allowed to ferment for a certain period before being incorporated into the final dough.

Starter
A fermented mixture of flour and water containing a colony of microorganisms including wild yeast and lactic acid bacteria. It's used to leaven bread.

Straight Dough
A bread-making method where all ingredients are mixed together at once, without the use of a preferment.

Stretch and Fold
S&F is a technique used during the bulk fermentation phase to strengthen the dough and help align the gluten structure. Instead of traditional kneading, the dough is gently stretched and then folded over itself. This process is typically repeated multiple times throughout bulk fermentation.

Tangzhong
A Chinese technique for bread-making, similar to the Japanese yudane method. It involves cooking a small portion of the flour with water (or milk) to create a slurry or roux. This process, which can be seen as a variant of scald, gelatinizes the starches in the flour, resulting in breads that are softer, fluffier, and have improved moisture retention. Once cooled, the Tangzhong is mixed with the remaining ingredients to produce the final dough.

Tight Crumb
Refers to a bread crumb (the soft inner part of the bread) that has small, uniform air holes.

Wild Yeast
Naturally occurring yeast, present in the environment and on the surface of grains, used in sourdough fermentation as opposed to commercial yeast. There's wild yeast on almost any surface of plants. The wild yeasts live in symbiosis with the plant providing a shield against pathogens and receiving sugars from the photosynthesis of the plant in return. When the plant becomes weak the wild yeasts can become parasitic and consume the host.

W-Value
A parameter representing the strength of flour in terms of its baking quality. The W-value, derived from the Chopin Alveograph test, measures the energy required to blow a bubble with the dough until it bursts. It is a direct indicator of the flour's ability to withstand the fermentation and baking processes. A higher W-value typically indicates a stronger flour, suitable for breads with high volume and longer fermentation times. Conversely, a lower W-value suggests a weaker flour, better suited for products requiring less structure, like cakes and pastries.

Yeast
Microorganisms that ferment the sugars present in the dough, producing carbon alcohol, carbon dioxide and heat; thereby causing the dough to rise.

Yudane
A Japanese method of bread-making which involves the preparation of a starter by mixing boiling water with bread flour in a specific ratio, typically 1:1 by weight. After mixing, the paste is left to cool to room temperature and then refrigerated overnight. The next day, it is combined with the remaining ingredients to make the dough. The Yudane method, essentially a type of scald, helps in improving the texture of the bread, making it softer and fluffier while also enhancing its shelf life.

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