THE SOURDOUGH JOURNEY

Inside the Invisible World of Sourdough Starters

A 14-Month DNA Study of Sourdough Starter Stability, Maturity, and Microbial Change

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Inside the Invisible World of Sourdough Starters

Two starters, from the same source, separated and maintained differently for 14 months. How much did they change, and why?

By Tom Cucuzza, ©The Sourdough Journey, 2026

Introduction

Since I began baking sourdough in 2019, I've always been fascinated by the mystery of sourdough starters. I've run many starter experiments over the years as I've tried to develop a deeper understanding of how sourdough starters work.

Every sourdough starter is unique and they are constantly changing. Sourdough bakers develop a relationship with their starters – feeding and caring for them each day. Bakers carefully monitor their starter's behavior after each feeding, and many starters (and their caretakers) fall into a predictable rhythm of behavior. Bakers learn that some starters prefer certain brands of flour. Some prefer to be fed at a certain time of day, and have a favorite warm spot in the kitchen. Sourdough starters and their relationship with their owner become very individualized and personalized.

Beneath this familiar routine lies an invisible world. Every sourdough starter also has a unique microbial "fingerprint" – a community of yeast and bacteria living together inside the jar. Each feeding introduces new microorganisms through the flour, water, and the baker's environment.

Starters may appear to be stable, but the microbial community is constantly changing, even if those changes are invisible to us.

Many people ask the question, "If you acquire an established sourdough starter from someone else and begin feeding it different flour, different water, in a different kitchen – how long does it take for it to change and become your unique starter?"

I set out to try to answer this question.

In February 2025, I obtained a mature sourdough starter from a commercial source. Over the next fourteen months I maintained it in my kitchen using a very different feeding schedule, four different types of flour, my local tap water, storage at different temperatures, and normal exposure to my kitchen environment.

After 14 months, in April 2026, I obtained a fresh sample of the original starter from the same source and sent samples of both to a laboratory for DNA sequencing, to compare how much the starters diverged during the separation period.

How much did the starters change over 14 months? The results were surprising, and challenged some widely held assumptions about how sourdough starters change over time.

The Science Behind This Experiment

There is a wealth of scientific research on sourdough starters, but it is quite fragmented and not easily digestible. I've summarized many concepts in this document, and I've included all of my sources and additional analysis in the appendices of this document. I encourage you to peruse the appendices for a deeper understanding of this experiment.

The scientific foundation for this experiment and my interpretation of the results draws largely on published research by Prof. Michael Gänzle and colleagues, Lucas von Gastrow/Delphine Sicard and colleagues, Rob Dunn/Elizabeth Landis and colleagues, Taheri et al., Pham et al., and Debra Wink. *See Appendix L: Sources and References* for more details.

PART 1: A TALE OF TWO STARTERS

In February 2025, I purchased a commercially available, live sourdough starter from a baker I knew, located in another state. He created the starter from scratch in 2020, and had carefully maintained it since its creation. The starter was never refrigerated, typically fed twice per day (minimum once per day), every day, and was used for a time in a commercial bakery to create tens of thousands of sourdough loaves. This was an established, mature starter, with a known provenance and very consistent maintenance history.

I chose this type of starter based on research by Michael Gänzle, et al. indicating that certain sourdough starters when fed daily, never refrigerated and often found in bakery environments can harbor a signature collection of very stable yeast and bacterial species – what Gänzle defines as a unique subcategory of mature sourdough starters known as a "Type 1" or "bakery" starter. More on this topic later.

Experiment Design

When designing the experiment, I considered two options:

1) Try to maintain the starter exactly the same as the original owner, or
2) Intentionally "mistreat" the starter to possibly find its "breaking point."

I chose the latter approach. Based on my research, I felt fairly confident that I would not see a material change in the starter if I followed the same maintenance protocol. I was more interested in stress testing the starter to possibly find the breaking point where it would change into something different.

Also, over the years of maintaining my own starters, I found it difficult to maintain a starter at room temperature with once or twice-a-day feedings every day, and never refrigerating it. I had proven to be a "bad starter parent" in the past, and I knew my limitations. I also had many out-of-town trips scheduled in 2025 and knew that I would need to put the starter on "vacation hold" quite frequently.

My known limitations set up a perfect "stress test" for a previously well-maintained starter. I designed the experiment as follows:

> *If I acquired a mature starter from a bakery and "intentionally mistreated" it with a less consistent maintenance routine, how long would it take for the microbial population of the starter to diverge from the original source?*

The initial planned duration of the experiment was 6 months. I ultimately ran the experiment for 14 months.

The following table compares the original owner's maintenance routine, to my modified routine.

Table 1: Comparison of Maintenance Methods

Maintenance factor	Source starter	My starter
Flour	Consistent flour	Four different supermarket flours
Water	Consistent water	13 months Cleveland filtered tap water; 1 month New York City unfiltered tap water
Feeding frequency	Twice daily, every day	Twice daily ~40% of the time; once daily ~50%; missed daily feeding ~10%
Approximate annual feedings	~730 per year	~475 per year
Refrigeration / cool storage	Never refrigerated; maintained at room temperature	Never refrigerated at 40°F (4°C); maintained at room temperature with periodic storage at 50°F (10°C)
Vacation holds	None	Six holds with no feedings for 1 to 3 weeks using a 1:3:3 feeding with a dry-flour top-off, stored at 50°F (10°C)

See ***Appendix A: Experiment Design and Maintenance History*** for more information on my maintenance routine and the vacation hold method.

What is a sourdough starter "fingerprint?"

Before we dive into the DNA results, it is important to understand the method used to analyze the starters. I have adopted a technique used in many academic studies. Using DNA sequencing, a report can be created for a sourdough starter. I call this the starter's "fingerprint."

The DNA testing evaluates:

- All identifiable yeast and bacterial species in the sample. This list is the **Species Profile.**
- The relative abundance within the yeast and bacterial populations, respectively. This is the **Population Mix**.

Within the yeast and bacteria populations, the report also subsets the **dominant** species. These are the collection of the most prevalent microbes that cumulatively represent at least 95% of the total population. There are often other species of microbes making up the balance of the population, and these are referred to as **"low abundance"** species. These are also part of the starter's unique fingerprint.

Sourdough starters typically have 1-2 dominant yeast species, and 1-3 dominant bacterial species, and often include other non-dominant microbes that round out the total population.

The following chart is an illustrative example of the DNA results making up a starter's "fingerprint."

What is a Sourdough Starter "Fingerprint?" Illustrative Example

Yeast Population

Yeast Species Profile	Population Mix %
Saccharomyces cerevisiae	71%
Kazachstania humilis	27%
Subtotal: Dominant Yeast Species	**98%**
Candida solani	<1%
Hanseniaspora uvarum	<1%
Candida saitoana	<1%
Total Yeast Population	**100%**

Five Identified Yeast Species
Two Dominant Species (combined ≥95%)
Three Low-Abundance Species

Bacteria Population

Bacteria Species Profile	Population Mix %
Lactobacillus plantarum	95%
Subtotal: Dominant Bacteria Species	**95%**
Lactobacillus brevis	2%
Lactobacillus sanfranciscensis	<1%
Pediococcus parvulus	<1%
Lactobacillus paralimentarius	<1%
Lactobacillus rossiae	<1%
Acetobacter malorum	<1%
Total Bacteria Population	**100%**

Seven Identified Bacteria Species
One Dominant Species (≥ 95%)
Six Low-Abundance Species

Fingerprint = Species Profile + Population Mix

Example data shown for explanation only; not from either starter in this study.

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What can we learn from a starter's "fingerprint?"

A starter's fingerprint can provide clues about how the starter may behave:

- **Yeasts primarily contribute to rising power.** Different yeast species can differ in their ability to produce carbon dioxide, and thrive under certain sourdough conditions. Yeast species can also influence flavor.
- **Bacteria primarily contribute acids and other compounds.** These influence flavor, acidity, fermentation, and other characteristics of sourdough bread.
- **Population mix matters too.** The relative proportion of species can impact performance. For example, if yeast A is a faster riser than yeast B, a starter containing 80% A and 20% B may perform differently from one containing 20% A and 80% B.
- **Some microbes frequently occur together.** Some yeast and bacteria combinations appear to "work well together" and may interact in ways that influence their growth and fermentation.
- **Some microbial combinations can also serve as markers.** Particular pairs of yeast and bacteria are often associated with specific types of sourdough starters and maintenance practices.

The DNA Sequencing Test

In April 2026, 14 months after beginning the test, I acquired a fresh sample of the source starter from the original owner. I sent that sample, along with a sample of my 14-month derivative starter, to LabID in Bolzano, Italy, for DNA sequencing.

Note: I did not compare my starter to the original February 2025 sample. I compared it to a fresh sample of the source starter that had been maintained by the original owner over the same 14-month period. Therefore, this experiment **compares the two starters after 14 months of separate maintenance**; it measures the **divergence** between the two starters and does not measure either starter's change from the original February 2025 starting point.

Any difference between the two samples could therefore reflect changes in **either or both** starters. Because the source starter continued under its established maintenance routine while I **intentionally changed** the maintenance conditions of my derivative starter, I discuss the observed differences in the context of their contrasting maintenance histories, but I cannot determine from these two samples where, or when, each change occurred.

This experiment was designed as a test of divergence between the two starters.

I have retained a frozen sample of the original starter from February 2025 and plan to test that sample in the future.

See *Appendix B: DNA Testing Protocol* for the testing protocol used in this study.

Important background information on DNA testing:

Species-level analysis. DNA sequencing identified organisms at the species level**, not the strain or sub-species level.** For example, researchers have identified and sequenced more than 1,000 genetically distinct strains of *Saccharomyces cerevisiae* – just one **species** of yeast we will see in this study.

Relative abundance. The results compare the relative abundance of yeast species and bacterial species separately within each group. They do not measure the overall yeast-to-bacteria ratio or the total number of microbial cells.

A Note to the Reader

This report documents **one** carefully designed, long-term comparison between two mature sourdough starters. It should be read as a well-documented case study, not as definitive proof of how all sourdough starters behave. My goal is to contribute one carefully observed experiment that can be compared with existing research and, I hope, inspire further discussion and experimentation.

How much did the starters' species profiles diverge?

The DNA results were surprising. After more than 500 feedings over 14 months using different flour, water, feeding schedules and storage methods, in different locations, both starters **had the same dominant species of yeast and bacteria.**

- Dominant yeast species, *K. humilis* and *S. cerevisiae*, together accounted for 98.0% and 95.8% of yeast reads, in the source starter and my starter respectively
- The dominant bacterial species, *F. sanfranciscensis* comprises more than 99% of the bacterial population in both starters.

Interestingly, several very low abundance species (less than approximately 1% of the population) were observed in both starters after fourteen months. These organisms may represent stable members of the sourdough ecosystem rather than transient contaminants.

The overall microbial stability was striking.

A small number of additional low-abundance species were observed uniquely in one starter or the other.

The details are provided in the following table.

Table 2: Comparison of the Two Starters' DNA Fingerprints

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Yeast Species	Source Starter	My Starter	Observations
Kazachstania humilis (Maudiozyma humilis)	57.3%	17.8%	**Same two dominant yeasts; relative dominance reversed**
Saccharomyces cerevisiae	40.7%	78.0%	
Dominant Yeast Subtotal	**98.0%**	**95.8%**	
Candida solani	<1%	2.1%	Higher in my starter
Hanseniaspora uvarum	<1%	<1%	Both <1%
Candida saitoana	<1%	<1%	Both <1%
Candida anglica	—	1.2%	Only in my starter
Bacterial Species			
Fructilactobacillus sanfranciscensis	99.7%	99.8%	**Essentially the same**
Dominant Bacteria Subtotal	**99.7%**	**99.8%**	
Leuconostoc citreum/holzapfelii	<1%	<1%	Both <1%
Leuconostoc falkenbergense	<1%	—	Only in source starter
Acetobacter orientalis	—	<1%	Only in my starter
Acetobacter malorum/cerevisiae	—	<1%	Only in my starter
Lactiplantibacillus sp.	—	<1%	Only in my starter

How did the yeast population compare?

The largest difference in the starters' makeup is **in the population mix of the two dominant yeast species.** Both starters were dominated by *K. humilis* and *S. cerevisiae*, but the proportions differed substantially.

K. humilis was dominant in the source starter (57.3%), while *S. cerevisiae* was dominant in my starter (78.0%).

Why did this difference in yeast dominance occur?

This experiment cannot determine how the difference arose. However, several possible explanations are worth considering:

- **Different maintenance routines may have altered the competitive balance between the two yeasts.** The source starter continued its highly consistent feeding routine, while my starter experienced more variable feeding intervals, temperatures and storage conditions. These differences may have favored *S. cerevisiae* relative to *K. humilis*.
- **Cool-storage "vacation hold" periods may have contributed to the shift.** My starter periodically experienced extended storage, unfed for weeks at a time, at approximately 50°F (10°C), a condition not experienced by the source starter.
- **Changes may also have occurred below the species level.** New strains or genetic variants could potentially have entered or emerged within either population and changed their competitive behavior. The DNA testing used in this experiment cannot resolve strain-level changes.

Interestingly, the smaller proportion of *K. humilis* in my starter, under my less intensive maintenance routine, is consistent with observations in published research by von Gastrow and colleagues, and with Michael Gänzle's interpretation of that work.

See *Appendix F: What Happens When Type 1 Maintenance Stops.*

How did the bacteria population compare?

The bacterial profiles showed even less divergence than the yeast profile. ***F. sanfranciscensis* was overwhelmingly dominant in both starters** at 99.7% in the source starter and 99.8% in my starter. It was essentially a bacterial monoculture at the species level.

There could also have been meaningful differences below the species level among strains or other genetic variants, but those changes were not measured by this test.

See *Appendix C: Additional DNA Results: Below-Species-Level Diversity* for additional information.

Are the two starters more similar or different?

While there are notable differences between the two starters, the two samples show striking similarities, particularly in the broader context of other sourdough starters.

- More than 60 yeast species have been identified in sourdough starters. Both starters share the **same two dominant yeast species.**
- Nearly 100 types of bacteria have been identified in sourdough starters. Both starters share the **same single dominant bacterium.**
- There are more than 10,000 potential dominant-species combinations calculated for typical starters. Both starters share the **same dominant species combination.**

- More than 500 other starter samples were analyzed across two separate studies. The dominant species profile of these two starters occurred in **approximately 1%** of the samples studied. **The species profile is uncommon.**

If a researcher randomly collected sourdough starters, finding two with this same uncommon combination of dominant species would be like finding two matching needles in different haystacks.

See Part 2: Table 3, Part 5: Tables 9-10, and Appendix I: Table 19 for more details.

Did the difference in yeast population mix impact the starter's performance?

As a baker I did not notice any change in rising times or other fermentation effects for most of the study period. Beginning in the 13th month of the study, I observed a sustained, material increase in the rising power of the starter.

Was this change in rising power related to the difference in yeast proportions? We do not know.

Some studies show differences in carbon dioxide (CO_2) generation when comparing *K. humilis* to *S. cerevisiae*, but more recent studies have found conflicting findings and indicate that there are **likely differences in performance at the subspecies level**.

Research indicates that CO_2 production is highly strain- and ecosystem-dependent, rather than determined simply by whether *K. humilis* or *S. cerevisiae* is dominant.

See *Appendix J: Changes in Starter Rising Power* for more details on this topic.

How did the starter's aroma and flavor change during the test period?

Over the course of the experiment, my starter developed a slightly more acidic aroma, particularly when under stress (e.g., after vacation hold periods). Yet at the end of the test period, the two starters still unmistakably **smelled like "siblings."** Based on aroma alone, I am confident I could have identified the source starter as the sibling of my starter in a blind lineup of 10 starters, and perhaps considerably more.

How did baking results change?

I did not observe any difference in baked loaves over the duration of the test period. In fact, when scanning my photo library, I was struck by the similarity of these two photos.

The photo on the left was one of the first loaves I baked with the new starter in February 2025, days after receiving it.

The photo on the right was a loaf I baked 10 months later, in December 2025. These two loaves look like they could have been baked from the same batch of dough on the same day. I cannot tell the difference in these photos without looking at the date stamp.

The change in starter strength impacted rising times, but had no measurable impact on the resulting baked loaves, in my opinion.

My starter continues to produce similar loaves today.

The Bottom Line

Despite all the details in this analysis, one result dominates everything else: after 14 months of separate maintenance and more than 500 feedings under my modified routine, **the two starters showed remarkably little divergence in their dominant species profiles**. Both contained the same dominant yeast and bacterial species.

The yeast population shows a material difference in its population mix, while the bacterial population is essentially the same.

Are the two starters "exactly the same?" Definitely not. The DNA results show differences between them, but their species profiles remain remarkably similar. I think of them as "close siblings," not "identical twins."

The ecological stability observed in this experiment is consistent with at least one other documented natural experiment. Two descendants of the same starter, separated for approximately 20 years, retained remarkably similar microbial fingerprints despite independent maintenance. See *Appendix G: A 20-Year Household Starter Comparison*.

PART 2: UNDERSTANDING STARTER MATURITY AND STABILITY

How is it possible there was so little difference between the two starters?

Many sourdough bakers may find these results surprising because of the popular conventional wisdom that if you take someone else's starter home and begin feeding it with your flour and water, it quickly becomes "your unique starter," with some people suggesting this can happen after a single feeding.

The results of my study point to two important, lesser-known aspects of sourdough starters:

1. **Mature sourdough starters behave very differently from newly created sourdough starters, and**
2. **A special class of mature sourdough starters appears to be extraordinarily resistant to change.**

Mature sourdough starters behave very differently from newly created starters

The reason many bakers may have expected my starter to change is because we are familiar with the process of creating new sourdough starters from scratch. A new starter is "seeded" with dormant yeast and bacterial cells typically found in flour, and to a lesser extent, water and the environment. But many bakers ask the question:

How is it possible that microbes in flour and the environment can establish a new starter, yet the same mechanism appears not to work in an established starter?

A newly created starter is like an **empty, fertile field**. Very small numbers of dormant microbial cells, typically introduced through flour, wake from their long slumber and begin to grow in a bath of fresh flour and water. Like seeds germinating in an open field, they have abundant resources and little competition from an established population.

Contrast that with a mature starter, which is more like a **dense, old-growth forest**. It is an established ecosystem: mature trees form the canopy, other species occupy the understory, and the forest floor is already covered with vegetation. A few seeds blowing into that forest face a very different challenge. They must find a place to germinate, compete for resources, and somehow establish themselves among organisms already well adapted to that environment.

Newly Created Starter

Mature, Established Starter

Feeding a mature starter with fresh flour is like a handful of seeds blowing into an old-growth forest. Arrival does not guarantee establishment.

But not all old-growth forests are the same.

All "Mature" Starters Are Not the Same

Now that we understand the difference between newly created and mature starters, there is an important second distinction: **all mature starters are not the same.**

The second reason both starters in this study remained remarkably similar is because the source starter belongs to a special sub-class of sourdough starters, known as "Type 1/ Bakery" starters **which are incredibly stable and resistant to change.**

Two Types of Mature Starters: "Household" and "Type 1" Starters

In 2023, I was introduced to the work of Michael Gänzle and his colleagues studying different types of sourdough starters. Their research describes an important distinction between mature starters maintained casually in households, and a special class of continuously propagated starters traditionally found in sourdough bakeries.

For purposes of this discussion, we will refer to:

- **Household Starters**: Typically (but not always) fed less frequently than daily, often refrigerated, and with more variable maintenance (e.g., different feeding ratios, flour types, temperatures).
- **Type I / Bakery Starters**: Typically maintained continuously at room or bakery temperatures and refreshed very frequently, generally at least once per day, often for many years, and refrigerated infrequently, if ever. While these are often referred to in various studies as "bakery" starters, they can also exist outside of a bakery environment. Note: For readability, I use the Arabic numeral 1 ('Type 1') rather than the Roman numeral I ('Type I').

Researchers discovered that different maintenance environments (e.g., less or more frequent feeding) can create different ecological pressures which tend to produce **distinctive microbial fingerprints.**

The Unusual Case of Type 1 Starters

Most sourdough bakers, especially home bakers, are unfamiliar with "Type 1" starters. These starters may look, smell, and behave much like ordinary household starters, but beneath the surface they are very different. They harbor distinctive communities of yeast and bacteria, shaped by years of continuous, intensive feeding. They are:

- **Uncommon.** Type 1 starters represent a relatively unusual, and more rare form of mature sourdough starter.
- **Shaped by intensive maintenance.** They typically develop over long periods of frequent, continuous feeding.
- **Microbially distinctive.** They possess a recognizable "fingerprint" of characteristic yeast and bacterial species.
- **Remarkably Stable.** Once established, these communities can demonstrate extraordinary stability and persistence.

This unusual class of starters is in effect, the **"battle-hardened"** starters of the sourdough world: highly specialized microbial ecosystems **capable of uncommon stability and persistence.** They appear to be extraordinarily resistant to change.

In a 2024 study of long-maintained sourdough starters, Pham and Gänzle examined three starter lineages sampled over periods ranging from 3 to 19 years. They found evidence that **the same bacterial strains had persisted in specific starters for nearly two decades.** Based on these findings, together with the much longer documented history of continuous maintenance, the authors concluded:

"We demonstrate that persistence over hundreds or thousands of years is possible, if not likely."

That is an extraordinary conclusion, and it stands in sharp contrast to much of the conventional wisdom surrounding sourdough starters, such as:

- *A starter is only as "old" as its most recent feeding.*
- *A starter eventually becomes more closely related to the flour used to feed it than to its original source.*
- *Bring someone else's starter into your kitchen and, after a few feedings, it becomes your own unique local starter.*

The research on Type 1 starters challenges all three of these beliefs, and much of what we know about sourdough starters.

Type 1 Starters are Uncommon

The vast majority of starters in the world are not Type 1 starters. Type 1 are a unique subclass of starters created through the unlikely convergence of three conditions:

Arrival: Showing up

Type 1 starters are distinguished by a **particular combination** of microbes: a bacterial community overwhelmingly dominated by *F. sanfranciscensis*, together with dominant yeasts typically belonging to *Kazachstania*, often alongside *S. cerevisiae*. *K. humilis* is a common yeast in this combination (Gänzle 2023).

The first hurdle is getting these microbes into the starter. Most intriguingly, *F. sanfranciscensis* is rarely detected in flour, so its arrival likely depends on another entry point and, sometimes, a little luck.

Note: In this paper, this distinctive microbial profile serves as an indicative marker of a Type 1 starter, rather than a definitive criterion. See Appendix E: Type 1 Starters.

Selection: Taking over

Showing up is only the beginning. These microbes then face the difficult challenge of **outcompeting others** to become dominant. Each sourdough starter typically has only one or two dominant species of yeast and one to three dominant species of bacteria. To gain dominance in an established starter, the arriving microbes must **displace** those already in control.

Frequent feeding cycles help create conditions that favor the characteristic Type 1 microbes.

Maintenance: Finding a caretaker

Lastly, once these microbes have gained dominance, they need to find the unlikely human caretaker to **feed and care** for them, feeding once or twice a day, never refrigerating, essentially forever. A tall order.

At the heart of this process is a cycle repeated perhaps thousands of times: feeding the starter.

More Feeding Cycles Create More Competition

Type 1 starters are unique because they are generally maintained and refreshed (discarded or used, and re-fed) much more frequently than household starters, and typically for years.

More feeding cycles create more and shorter rounds of competition for microbial dominance. Each feeding kicks off a new round of competition. Organisms best adapted to that intensive feeding schedule gain the advantage.

In a Type 1 starter, frequent discarding and feeding create particularly demanding conditions. Michael Gänzle describes this as putting "very stringent selection" on the "**fastest-growing organisms,**" and describes this type of intensive maintenance routine as a **"never-ending ultramarathon."**

Fast-growing organisms thrive in a fast-moving environment: slow-growing organisms get left behind.

Survival of the Fittest

Continuous refreshments (discarding and re-feeding a sourdough starter) create what scientists call **selection pressure**. In more familiar terms, this is "survival of the fittest." However, in a sourdough starter, survival of the fittest does not mean survival of the "strongest" organism. Survival of the fittest means, quite literally, survival of the **best fit**.

In a sourdough starter, the "fittest" organisms are those **best suited to the complete set of conditions in the starter**.

Natural Selection, In a Jar

Each feeding restarts a new Darwinian competition within a starter:

- **Competition:** Newcomers must compete for limited resources in an established microbial community.
- **Natural selection:** Organisms best suited to the temperature, food source, hydration, acidity, and feeding interval gain an advantage. More frequent feedings favor organisms that reproduce quickly under those conditions.
- **Dominance:** To become dominant, emerging competitors must displace established populations, which can be difficult.
- **Co-occurrence:** Some yeasts and bacteria form compatible, sometimes mutually beneficial partnerships. Newcomers can struggle to compete against an established microbial "team."
- **Stability:** Consistent maintenance keeps favoring the organisms that rose to dominance under that routine.

The Sourdough Olympians

Because of their intensive maintenance routine, what emerges in Type 1 starters are the **Olympic athletes of the sourdough world**: elite performers, selected through endless competition for survival and dominance.

Aren't new competitors also introduced with each feeding?

Yes, but new competitors are facing elite athletes perpetually at their prime, because unlike human athletes, the microbial Olympians do not age, lose their abilities, or retire. Yeast and bacteria reproduce by making new cells that are, in practical terms, **copies of themselves.** It is less like Olympic swimming champion, Michael Phelps, teaching his son to swim and more like **Michael Phelps cloning himself before each race, forever**.

The Universe of Microbial Combinations

To better understand the uniqueness of Type 1 starters, it is helpful to compare them to the broader universe of typical Household starters to fully illustrate the stark differences.

Using two landmark studies of sourdough microbial communities, Landis et al. and von Gastrow et al., we can compare the species found across DNA studies of 546 sourdough starters. Together, these studies provide a comparison of mostly Household starters with mature bakery starters maintained under varied practices.

The two studies reveal two distinctly different microbial worlds.

Looking at DNA results across more than 500 sourdough starters can feel a bit like looking into the night sky for the first time. One initially sees what appear to be an uncountable number of points of light. But then we learn there is structure in the night sky – galaxies, constellations, stars, and planets. Once these patterns are understood, we begin to see order and structure in the seeming randomness.

The following "walkdown" serves a similar purpose. It starts with the "night sky" of organisms in sourdough starters and gives us a language for organizing the apparent microbial chaos, revealing the patterns underneath.

The following table identifies the count and likely combinations of species typically found in Household versus Type 1 starters.

Compare the two columns of data in the table, remembering that Type 1 starters, through generations of competition, result in a small set of the most highly adapted and specialized microbes.

Table 3: Yeast and Bacteria Species in Sourdough Starter Populations

	"Household" (*Landis*)	**"Type 1" (*von Gastrow*)**
Yeast Species Identified	61	14
Bacteria Species Identified	93	11
Possible Total Combinations	**2.28×10^{46}**	**33.5 million**
Commonly Found Yeast Species	12	5
Commonly Found Bacteria Species	9	2
Possible Commonly Found Combinations	**2 million**	**93**
Typical Dominant Yeast Species in a Starter	1-2	1-2
Typical Dominant Bacteria Species in a Starter	1-3	1-2
Likely Dominant Yeast + Bacteria Combinations	10,062	45

"Identified" = species detected at any abundance. A few unnamed clusters are at taxa level.
"Commonly Found" = species occurring in at least 10% of samples.
"Typical" = the range of species counts needed to collectively account for ≥95% abundance per sample, within yeast and bacteria separately.
"Likely" = calculated possible profiles combining the Commonly Found species within the Typical range of species counts.
***See Appendix H: Landis Sample Size Adjustment* for more details on this sampling methodology.**

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As the table walks down from the enormous number of mathematically possible combinations to the much smaller number of likely dominant combinations, something important becomes clear: **there is much more order in the microbial universe than we might expect.** Millions (or more) possible combinations reduce to a relatively small number of identified species and commonly recurring yeast and bacteria combinations.

The contrast between "Household" and "Type 1" starters is especially striking throughout the table. Household starters are made up of a panoply of microbial combinations, whereas Type 1 starters consist of a very small number of specific microbial species and combinations. For example, Type 1 starters only have 5 commonly found yeast species and 2 commonly found bacteria species.

Using the calculations above, there are about 10,000 possible species combinations or "profiles" for household starters, compared with only 45 for Type 1 starters.

To put these numbers in perspective, imagine you wanted to assemble a starter collection containing one example of every possible combination of commonly found species based on the table above. For Household starters, you would need more than 10,000 starters (assuming no duplicates). For Type 1 starters, you would need only 45 unique starters to represent every possible combination.

If Type 1 starters are the Olympians of the sourdough starter world, Household starters are the amateur, college, and professional athletes in all sports. A large pool of talent with a wide range of capabilities. The Olympians are a smaller pool of highly-specialized athletes.

Are Type 1 starters "better" than Household starters?

Not necessarily. Type 1 starters are more specialized, not universally better.

Sourdough starters become highly adapted to the conditions under which they are maintained.

Type 1 starters are shaped by frequent, rigorous feeding schedules typical of production bakeries. Household starters are shaped by very different routines, often including refrigeration, less frequent feeding, changing temperatures, and longer periods between uses.

A Type 1 starter therefore performs best under the same intensive maintenance environment that created it. Move that starter into a home kitchen, refrigerate it, and feed it only once a week, and those conditions no longer favor the same microbial community. Over time, the starter may begin to change.

Likewise, a mature household starter can become very well adapted to a much more flexible maintenance routine. It may tolerate refrigeration and infrequent feeding extremely well without requiring the daily attention typical of a bakery starter.

Both can produce excellent sourdough bread. They are optimized for different jobs.

For a commercial bakery, however, the characteristics of a Type 1 starter have particular value. Its microbial community tends to be **stable and predictable**, two critical attributes when bread must be produced every day on a schedule. Type 1 starters may also favor rapidly reproducing and acid-tolerant microbes that perform especially well in a bakery environment.

While Type 1 starters may be more stable and predictable, they are also more demanding. They are, quite literally, **high-maintenance starters**.

For a home baker, the advantages of "stability and predictability" may be less important than **flexibility**. A household starter that can spend days in the refrigerator and reliably return to activity when needed may be better suited to the way that baker needs to use it.

Type 1 is not a quality grade.
It is a highly specialized adaptation to a particular maintenance environment.

I personally know many bakers producing extraordinary sourdough loaves using starters they created themselves within the past few years. I reached out to several of them while researching this study and confirmed that they do not follow a Type 1 maintenance protocol; some routinely refrigerate their starters and feed them less frequently than daily.

How do I know if my starter is "Type 1?"

You usually cannot tell by looking at it.

A Type 1 starter may look, smell, rise, and bake very much like an ordinary household starter. Its maintenance history can provide important clues: long-term, frequent feeding, little or no refrigeration, and a highly consistent routine are all characteristic of traditional Type 1 maintenance.

But those clues are not enough to confirm the classification. We must also look at the microbial population of the starter, which can only be determined through a DNA test.

The Signature Markers of Household and Type 1 Starters

The following table summarizes the key differences between typical Household and Type 1 starters, including their maintenance practices and microbial profiles.

Table 4: Household vs. Type 1 Starters

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Characteristic	Household	Type 1 / "Bakery"
Maintenance	Less frequent, more variable; often refrigerated	Continuous, frequent refreshments; traditionally not refrigerated
Feeding frequency	Often weekly, rarely daily *(~50–100 feedings/year)*	Daily or more *(365+ feedings/year)*
Age* / maturity	Any mature age; may be months to decades old	Typically long-established, mature starters maintained continuously over many feeding cycles; no specific age defines Type 1
Microbial profile	Generally broader and more mixed	Generally narrower and more concentrated
Typical yeast	Wide variety; ***S. cerevisiae*** **frequently dominant;** *Kazachstania* species less commonly dominant	***K. humilis*** or other ***Kazachstania*** species frequently dominant; ***S. cerevisiae*** may coexist
Typical bacteria	Wide variety of dominant bacterial species; *F. sanfranciscensis* **infrequently dominant**	***F. sanfranciscensis*** frequently overwhelmingly dominant

***Note: Type 1 starters are usually "old," but they are not Type 1 because they are old. They are Type 1 because they have been continuously shaped by intensive maintenance over many generations.**
See *Appendix E: Type 1 Starters* for more information on Type 1 starters.

Even a starter maintained under classic bakery conditions is only presumably Type 1 until we examine its microbes. DNA testing lets us check whether its species profile matches the characteristic Type 1 pattern.

What do Household and Type 1 DNA fingerprints look like?

Let's bring this to life with two real examples for comparison.

The following two examples are microbial fingerprints from the Household and Type 1 starters found in the Landis and von Gastrow studies. I selected these two starters to illustrate the different **microbial patterns** typically found in each group.

Household vs. Type 1 Starters: Two Examples

HOUSEHOLD STARTER

Landis #395
50-year-old household starter
Refrigerated; fed weekly

YEAST	Mix %
Saccharomyces cerevisiae	**82.7%**
Wickerhamomyces anomalus	**11.1%**
Cyberlindnera fabianii	**1.4%**
Candida santamariae	1.2%
Pichia norvegensis	<1%
Eremothecium coryli	<1%
Candida sake	<1%
Eremothecium gossypii	<1%
Candida solani	<1%
Total Yeast Population	**100%**

BACTERIA	Mix %
Lactobacillus paralimentarius	**51.0%**
Lactobacillus brevis	**36.7%**
Lactobacillus plantarum	**11.9%**
Acetobacter malorum	<1%
Total Bacteria Population	**100%**

TYPE 1 STARTER

von Gastrow #B11
Mature French bakery starter used in routine bakery bread production

YEAST	Mix %
Kazachstania humilis	**93.9%**
Saccharomyces cerevisiae	**5.7%**
Kazachstania barnettii	<1%
Total Yeast Population	**100%**

BACTERIA	Mix %
Fructilactobacillus sanfranciscensis	**100.0%**
Total Bacteria Population	**100%**

Observations

- Household Starter: a broad, mixed species profile of both yeast and bacteria
- Type 1 Starter: a narrow, more concentrated species profile, with singular dominance in this example
- The signature Type 1 species combination of *K. humilis* and *F. sanfranciscensis* is **rarely found in household starters**
- For each example, the species shown in **blue bold** represent a 'species combination,' as discussed in the Walkdown (sum ≥ 95%)

What kind of starter is the Source Starter in this study?

Let's compare what we know about the source starter to the Type 1 guidance.

Table 5: Type 1 Starter Classification Guidance

Characteristic	Type 1 / "Bakery" Guidance	Source Starter	Type 1 Marker
Maintenance	Continuous, frequent refreshments; traditionally not refrigerated	Twice-a-day feedings, never refrigerated	✓
Feeding frequency	Daily or more *(365+ feedings/year)*	700+ feedings per year	✓
Age* / maturity	Typically long-established, mature starters maintained continuously over many feeding cycles; no specific age defines Type 1	Created in 2020. DNA tested in 2026.	✓
Microbial profile	Generally narrower and more concentrated	One dominant bacterial species, two dominant yeast species. Very narrow species profile with a few low-abundance species.	✓
Typical yeast	***K. humilis*** or other ***Kazachstania*** species frequently dominant; ***S. cerevisiae*** may coexist	***K. humilis*** *dominance, with* ***S. cerevisiae*** *coexisting*	✓
Typical bacteria	***F. sanfranciscensis*** frequently overwhelmingly dominant	***F. sanfranciscensis*** overwhelmingly dominant	✓

***Note: Type 1 starters are usually "old," but they are not Type 1 because they are old. They are Type 1 because they have been continuously shaped by intensive maintenance over many generations.**
The source starter's general microbial pattern was also very uncommon in the Landis Household cohort at 1.6% occurrence.
See ***Appendix E: Type 1 Starters*** for more information.

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Under the definition used in this paper, that makes the source starter a **confirmed Type 1 starter**.

This finding fundamentally changes how the experiment should be interpreted.

Why did the two starters retain such similar microbial signatures after 500+ feedings in different locations?

Largely because the source was a Type 1 starter.

Did my starter remain a Type 1 Starter?

Yes. If we compare my starter to the guidance in the table above, the only material departure from the source starter comparison is the maintenance protocol, but it still meets the maintenance guideline.

During periods of normal maintenance, my starter was generally fed once or twice a day. Even after accounting for vacation holds and missed feedings, its estimated feeding frequency still averaged more than once per day across a full year. It was never stored at typical refrigerator temperature of 40°F (4°C). It was occasionally stored at 50°F (10°C).

My maintenance method clearly **tested the boundaries** of traditional Type 1 maintenance, by design, while still averaging more than one feeding per day on an annualized basis, albeit less consistently.

Despite those deviations, its final microbial fingerprint remained strongly consistent with a Type 1 profile:

- The dominant organisms were *K. humilis*, *S. cerevisiae*, and *F. sanfranciscensis*
- Its fingerprint was consistent with the Type 1 species pattern of the source starter.

The general microbial pattern found in my starter is also very uncommon among Household starters, occurring in 0.8% of the Landis dataset.

See *Appendix F: What Happens When Type 1 Maintenance Stops* for more information.

What would my starter have looked like if it had changed from Type 1 to Household?

If my starter had reverted from Type 1 to Household, I would expect the DNA profile to lose the concentrated Type 1 signature and move toward the broader, more heterogeneous Household pattern. That could include:

- **Loss of overwhelming *F. sanfranciscensis* dominance**, with one or more other bacterial species becoming substantial or dominant.
- **Loss of the characteristic *Kazachstania* signal**, especially if *K. humilis* disappeared or became only a minor component.
- **Greater overall species diversity**, rather than the narrow, highly concentrated community typical of Type 1 starters.
- **A more Household-like yeast profile**, potentially including *S. cerevisiae* dominance without *K. humilis* or the accompanying Type 1 bacterial pattern.

None of these were observed. The core Type 1 architecture remained intact.

Without DNA testing, there would have been no reliable way to know.

See *Appendix F: What Happens When Type 1 Maintenance Stops* for more information.

The Mysterious Arrival of *F. sanfranciscensis*

As we wrap up our discussion of Type 1 starters, one important question remains.

One of the defining characteristics of Type 1 starters is the dominance of *F. sanfranciscensis*. Yet studies have shown that this bacterium is **rarely detected in flour** (Taheri et al. 2025).

If one of the defining organisms of a Type 1 starter is rarely detected in flour, **where does it come from?**

Research suggests several possible sources, including insects and the gastrointestinal tracts of certain animals. But its precise route into a sourdough starter remains uncertain.

This introduces an important distinction in how Type 1 starters develop. Frequent feeding can favor certain yeast and bacteria, but it cannot select for organisms that are not there in the first place. **The right organisms must first be present, whether they arrive from the environment or were already there in very small numbers.**

See *Appendix D: Newly Created Starters – The Research* for more information on this fascinating topic.

Additional Questions

Where *F. sanfranciscensis* comes from is just one of the questions raised by these findings. The following FAQ section explores others, and what they mean for sourdough bakers.

PART 3: FREQUENTLY ASKED QUESTIONS

Why should home bakers care about Type 1 starters?

Some of the most influential sourdough advice was developed by professional bakers using starters that may behave very differently from the starters maintained in home kitchens.

This has practical consequences.

For example, the most popular sourdough baking books rarely discuss how to rehabilitate an overly acidic, weak starter, because that is not the type of starter the authors, production bakers, typically work with. Production bakery starters are refreshed frequently and kept in consistently strong condition.

One popular book describes bulk fermentation targets in which dough can increase dramatically in volume, in some cases approaching a tripling. A vigorous production starter may be capable of driving that kind of fermentation. A typical household starter may not.

Some sourdough educators go so far as to recommend following advice only from “production bakers.”

For years, I have cautioned home bakers about comparing their starter performance directly with what they see in professional bakeries and books. The obvious explanation was maintenance: professional starters are fed frequently, used continuously, and kept under tightly controlled conditions.

The Type 1 research adds another possible explanation.

Some long-established production starters may not simply be healthier versions of household starters. They may be **microbiologically different ecosystems**, shaped by years of intensive bakery maintenance.

In other words, a home baker can follow the same flour, hydration, temperature, inoculation, and timing and still get a different result because the starter itself may not have the same fermentation capacity, microbial balance, or response to repeated feeding.

That does not make the professional advice wrong. It simply means the advice from professional bakers may be based on a type of starter not typically used by home bakers.

What does the bread taste like?

Compared with other starters I’ve used over the years, this starter produces bread with a relatively mild flavor.

My previous starters made loaves that were more sour, and to my taste, more complex. This starter is exceptionally strong and fast-rising, but the flavor is somewhat **“one note”**: mildly sour, clearly sourdough, but not especially distinctive. In fact, I almost stopped using it after the first month because I simply did not love the flavor.

Over time, I adjusted my bread formula to use longer cold fermentation and the addition of ancient grains to develop my preferred flavor profile.

Is it possible to buy a "heritage" starter and maintain it somewhere else without changing it?

Short Answer: Yes. I now believe it is possible.

Commercial starters are often sold with claims such as:

- "100-year-old starter from France"
- "Genuine California Gold Rush starter"
- "A family starter handed down through generations"

Those claims are often dismissed because of the popular idea that a starter quickly becomes "local" once it is moved, fed with different flour and water, and maintained in a different kitchen.

My experiment changed my view of that.

A mature starter, especially a Type 1 starter, is already a highly established microbial ecosystem. If you move it to a new location but maintain it under similar conditions, there is good reason to believe that much of its microbial identity can persist.

The key is likely the maintenance routine more than the geography.

This is consistent with findings from Landis et al. (2021), who studied 500 sourdough starters collected across four continents. As Elizabeth Landis explained, "And we found that where the baker lives was not an important factor in the microbiology of sourdough starters."

Change the maintenance routine substantially and the starter may drift. But in my experiment, after 14 months of separate maintenance, hundreds of feedings, different locations, different flours, and even different maintenance routines, the two starters still showed remarkable similarities in flavor, functionality, and dominant microbial species.

So yes, I believe you can move a mature heritage starter to a different location and preserve much of what made it distinctive in the first place – especially with consistent maintenance.

Before this experiment, I was skeptical. I'm not anymore.

See *Appendix E: Type 1 Starters* for more information on this topic.

Is There Really Such a Thing as a "100-Year-Old Starter?"

Short Answer: Yes. But "100 years old" does not mean that the same individual microbial cells have survived for 100 years.

The individual yeast and bacterial cells in a starter are constantly being replaced. Yeast reproduces primarily by budding, and bacteria by cell division, **creating daughter cells that are genetic copies** of the cells that came before them. Over time, the original cells disappear, but their **microbial lineages continue through repeated reproduction**.

A 100-year-old starter is not a jar containing 100-year-old cells. It is a continuously maintained biological lineage whose descendants, which are copies of the parent, can persist from one generation to the next. *Note: Mutations and occasional sexual recombination or hybridization can introduce genetic changes into the population over time. Sourdough starters are not static.*

The more important question, then, is whether the microbial lineages that define a mature starter can remain stable across very long periods of time.

The evidence says they can.

Long-maintained sourdough starters have shown remarkable microbial continuity over decades. In one documented case, descendants of the same starter were maintained independently for approximately 20 years and later showed strikingly similar microbial fingerprints despite their long separation and different maintenance histories.

As discussed, Pham and Gänzle go even further. After analyzing starters' DNA over almost 20 years, they concluded that persistence of sourdough-associated microbial lineages for **"hundreds or thousands of years is possible, if not likely."**

DNA testing cannot prove the veracity of a "100-year-old" claim, but I now believe that the idea of a "100-year-old starter" is not necessarily folklore. The individual cells are continuously replaced, but the direct lineage can persist.

What about the impact of geography?

Geography has been shown to have little impact on sourdough microbiology. Based on the Landis et al. study of 2021, the findings were quite clear:

> *"Our comprehensive sampling demonstrates that geographic location does not determine sourdough microbial composition"*

Is *F. sanfranciscensis* the bacterium that makes "San Francisco Sourdough"?

Short Answer: No.

F. sanfranciscensis was first identified in San Francisco, which is why it carries the city's name. But later research found the same bacterium in sourdough starters all over the world. It is not unique to San Francisco.

It also does not, by itself, create the classic "San Francisco sourdough" flavor.

That flavor is the product of the whole fermentation system: the microbial community, fermentation time, temperature, dough acidity, flour, and production method. *F. sanfranciscensis* may contribute to that flavor, but its presence alone does not make a bread taste like classic San Francisco sourdough.

That is easy to see today. Many modern sourdough bakeries around the world use starters that likely contain *F. sanfranciscensis*, yet produce breads with very different flavor profiles from the sharply tangy style historically associated with “San Francisco sourdough.”

So, the name is historically important, but biologically misleading. “Sanfranciscensis” tells us where the bacterium was first identified, not its exclusive origin, or what flavor it produces.

Can a “household” starter be turned into a Type 1 starter by feeding it every day?

Short Answer: Not necessarily.

Frequent feeding is an important part of developing and maintaining a Type 1 starter, but feeding alone cannot guarantee that you'll get there. Two requirements are relevant here.

Arrival: The microorganisms characteristic of Type 1 starters first have to **get into the starter**. Some important species, most notably *F. sanfranciscensis*, are not commonly detected in flour and may need to arrive through other vectors, including water, human contact, insects, other starters, or the surrounding environment. You cannot select for a microorganism that isn't there.

Selection: Once the right organisms are present, repeated discard-and-feed cycles create an environment that favors the species best adapted to frequent refreshment. Over many generations, these organisms can outcompete other species and become dominant. **We don't know how long this process takes.** It may take months or years.

However, simply feeding a starter every day does not guarantee that it will develop the characteristic microbial fingerprint of a Type 1 starter, because the competition that drives natural selection depends on all aspects of maintenance including flour types, feeding ratio, hydration, temperature, presence of other organisms, etc.

Can I Create a Type 1 Starter? How Long Would It Take?

Can a Type 1 starter be created from scratch? Could an established Household starter become Type 1? Could I accelerate the process by feeding more frequently? Could I create one in a laboratory by introducing the desired microorganisms? And once a Type 1 microbial community becomes established, how stable would it be?

These are fascinating questions, and the short answer is that **we don't know**.

However, the Arrival, Selection, and Maintenance framework included in Part 5, *The Maturity Map*, provides a useful way to explore these possibilities, even when definitive scientific answers are unavailable.

For a more detailed discussion of these questions, including examples and supporting research, see *Appendix E: Type 1 Starters.*

Can a Type 1 starter revert back to a Household starter if it is not maintained consistently and/or is refrigerated?

Probably, but we do not yet know how long that transition takes or exactly what the intermediate stages look like.

We know that Type 1 starters are associated with sustained, frequent propagation under stable conditions. If that consistency is disrupted for long enough, especially through infrequent feeding and prolonged refrigeration, the community could drift away from the characteristic Type 1 profile.

My 14-month study was designed, in part, to test those boundaries. The starter experienced extended unfed periods, cool storage at 50°F (10°C), changes in flour, temperature, and location, yet its Type 1 profile did not "break." The dominant species remained the same, and *F. sanfranciscensis* remained overwhelmingly dominant. So, whatever the reversion threshold is, this maintenance history did not cross it.

The Landis Household dataset raises an intriguing possibility. Some starters contained *F. sanfranciscensis* without a strong *Kazachstania* signal, while others contained *Kazachstania* species without *F. sanfranciscensis* dominance.

Could some of these be former Type 1 starters caught somewhere along a reversion pathway? Possibly. But without longitudinal DNA data and detailed maintenance histories, we cannot tell whether they are reverted Type 1 starters, independently assembled Household communities, or something in between.

Type 1 reversion is biologically plausible and probably occurs, but the timing, sequence, and microbial pathway have not been well established. My study shows that a mature Type 1 community can persist through substantial maintenance disruption without reverting.

A related 2026 study by Wardhana et al. explores the effects of deliberately harsh maintenance conditions on two industrial bakery starters with a characteristic Type 1 species profile. The study demonstrates both extraordinary stability and the eventual loss of the characteristic Type 1 yeast and bacteria species in one starter.

See *Appendix F: What Happens When Type 1 Maintenance Stops* for more details on this study.

If I get my starter's DNA tested, how can I determine what type of starter it is?

In Part 5 of this document, you will find *The Starter Maturity Model: A Complete Guide*. The guide includes:

- **The Starter Maturity Map**: A visual guide to help understand how starters transition through the lifecycle of New, Household and Type 1 Starters.
- **Microbial Signposts**: A simplified summary of key microbial "markers" to help identify where your starter resides on the Maturity Map.

- **Signature Species Patterns:** A summary of the typically recurring combinations of yeast and lactic acid bacteria to help you understand how your starter's unique microbial profile compares to other sourdough starters.

How much does it cost to get a starter DNA tested, and where?

In April 2026, I used the sourdough starter DNA sequencing service at **LabID in Bolzano, Italy**. The cost was approximately **$400 per sample**.

Testing is generally run in batches rather than continuously, so check LabID's current testing schedule before planning to send a sample.

Where did I buy the original source starter?

I have intentionally kept the commercial source anonymous because this is a research paper, not a product evaluation.

For this analysis, what matters is the starter's **maintenance history and microbial fingerprint**, both of which are documented in the paper.

Additional FAQs Addressed in Appendices

Is the 2026 source starter sample representative of the original 2025 source?

How do microorganisms enter a new sourdough starter?

What Is a Type 1 Sourdough Starter?

How does *F. sanfranciscensis* get into a sourdough starter?

Why is *S. cerevisiae* so dominant in Household starters, but less characteristic of Type 1 starters?

Can a Household starter perform as well as a Type 1 starter?

What does "Reversion" mean?

Can Reversion be reversed?

If I were to begin feeding my starter used in this experiment twice a day, would the population mix revert back to *K. humilis* dominance?

If a baker stops feeding a Type 1 starter every day, will it lose its Type 1 identity?

Does sample size affect the Walkdown?

Does *S. cerevisiae* produce more CO_2 than *K. humilis*?

PART 4: SUMMARY AND CONCLUSIONS

What Did I Learn?

When I began this experiment, I was already familiar with the research on Type 1 starters and specifically sought out a starter with the history and maintenance characteristics of this unusual class. I expected it to be stable. That was part of the reason I chose it.

But Type 1 starter stability was still, to me, largely an academic concept. I understood the science, but I had never tested just how far that stability could be pushed.

Over the next 14 months, I fed this starter more than 500 times, sometimes wondering whether the experiment even made sense. I changed its flour, water, feeding ratios, feeding schedules, temperatures, and storage methods. I traveled with it. I skipped daily feedings. I left it unfed for weeks at a time. By the standards under which it had been maintained for years, I mistreated it.

After those 14 months the two starters differed.

The yeast population proportions diverged. The aroma changed. Its rising power appears to have changed.

But the **core microbial ecosystem held**. No differing dominant species were found, despite the different locations and maintenance routines.

Both starters ended the experiment with the same two dominant yeast species. The dominant bacterium, *F. sanfranciscensis,* appeared in both starters at approximately 99% of the bacterial population. Even several organisms representing a very small percentage of the population were found in both starters. The science led me to believe this could happen. What I did not expect was the **magnitude of the stability**.

But what began as a simple comparison of two starters eventually became a months-long odyssey through ecological succession, microbial persistence, decades-old starter lineages, DNA databases and many scientific studies.

I no longer needed to understand what happened. I needed to understand why.

Summary

1. Sourdough starters are constantly changing.

Sourdough starters often appear stable in our kitchens, but a sourdough starter is a living ecosystem and an open system. Flour, water, temperature, feeding frequency, hydration, and countless other environmental influences continually create opportunities for microbial populations to change.

Even when the dominant organisms remain the same, their proportions can shift. Organisms can appear or disappear.

The two starters in this experiment did not remain identical. They diverged, particularly in their yeast population mix, and in some of their observable characteristics.

2. Mature sourdough starters can be remarkably stable.

Change does not necessarily mean that a starter has lost its microbial identity.

Both starters were dominated by the same species, despite over 500 feedings in two different locations.

This is consistent with research showing that mature sourdough ecosystems can remain stable for years or even decades. And, the findings challenge the conventional idea that an established starter somehow becomes a completely "new starter" after simply changing the flour, location, or feeding schedule.

3. Mature starters behave differently from newly created starters.

What we know about how new starters are created from scratch has misinformed our understanding of how mature starters operate.

A new starter is a "fertile field" where a chaotic battle for dominance plays out among a somewhat random collection of microbial species introduced through flour and the environment.

A mature starter is very different. A sourdough starter is not simply an ongoing collection of all the microbes it encounters. New organisms from external sources enter an already occupied ecosystem with a stable, established population competing intensely for resources, and already optimized for that environment.

Mature starters are less likely to be influenced by the microbes in flour, water, and the environment than new starters.

4. Maintenance is one of the most powerful forces shaping a starter.

One likely reason the two starters showed little divergence in their dominant species profiles is that the source was a Type 1 starter, shaped by years of twice-daily feeding, no refrigeration, and highly consistent maintenance.

Intensive feeding sets up a daily contest for survival and dominance, "survival of the fittest" in the literal sense: not survival of the strongest organisms, but survival of the organisms **best fitted to the conditions** repeatedly created for them.

Over time, this repeated competition can produce a highly specialized microbial community that is remarkably **resistant to change**.

5. Starters appear to exist along a maturity continuum.

New starters, Household starters, and Type 1 starters should not be viewed simply as younger and older versions of the same thing. As starters traverse the continuum, they take on **different microbial profiles.**

- New starters sort through the chaos of the "microbial lottery," and establish a somewhat random initial microbial profile.
- Household starters mature into diverse, individualized microbial profiles shaped by and adapted to the varied routines of a particular baker and kitchen.

- Type 1 starters consist of unusually narrow and predictable microbial profiles, shaped by frequent propagation over long periods of time.

However, when maintenance conditions change, Type 1 starters can revert, partially or substantially, toward microbial patterns found in Household starters.

Starters can transition through these stages over their lifetimes, as they are continuously impacted by maintenance routines and their environment.

The Starter Maturity Map developed in Part 5 of this paper is my attempt to put these observations into a cohesive framework.

6. Stability and change are not opposites.

This may be the most important thing I learned.

When I began this project, I thought stability meant that a mature starter resisted change. I now have a different understanding. A healthy, mature starter may be stable precisely because it **can change** without losing its ecological identity. Populations shift as conditions change. Some organisms gain ground and others lose it. A mature starter adapts to change without losing its identity. Adaptability is a strength.

What the baker experiences on the outside as "consistency" may be the result of the continuous change occurring inside the jar.

Our sourdough starters are **stable, but never static.**

7. Starter DNA testing gives us new insights into the invisible world of sourdough starters.

Now that DNA testing is commercially available to sourdough bakers, not just the scientific community, it opens the door for bakers to adopt the role of citizen scientists. Together we can learn more about our own sourdough starters, and by sharing results, learn more about the vast invisible world of sourdough starter microbiology.

Final Thoughts

For years, I watched my starter from the outside.

I watched how quickly it rose, how it looked, how it smelled, how reliably it fermented dough, and how its behavior changed when I changed the way I cared for it.

This experiment gave me a glimpse into what was happening inside the jar.

A starter is not frozen in time. Inside the jar, microbial populations continually compete and respond to the environment the baker creates.

That also changes how I think about the relationship between a baker and a sourdough starter.

We often describe sourdough starters as "wild" organisms that we somehow capture in a jar. But a sourdough starter is, in an important sense, **domesticated**. It requires human assistance to survive.

Humans create the environment. We choose the flour. We control the temperature and hydration. We decide when it eats and how frequently it reproduces. We literally decide how much of the population survives with each discard and feeding.

Type 1 starters may represent one of the most "**highly domesticated**" forms of that relationship. Their microbial communities have been shaped by thousands of repeated human interactions and most importantly, Type 1 starters **depend most** upon our ongoing support for their continued survival.

Domestication is an interesting word, because after living with a sourdough starter for a while, the direction of control becomes less obvious.

We adjust our schedules because the starter needs to be fed. We change its temperature when it is fermenting too quickly. We bring it with us when we travel. We arrange for someone to care for it when we leave. Bakers have carried particular starters across oceans and preserved them through generations. And in return, they give us bread.

We think we are maintaining our starters.

From another perspective, perhaps sourdough starters have persuaded generations of humans to provide them with food, shelter, and a remarkably effective means of reproduction and **survival**.

Perhaps that is the final lesson hiding inside the jar.

"The story of human civilization … can all be told by a loaf of freshly-baked, warm-from-the-oven sourdough bread."
— Eric Pallant, The Rise and Fall of Sourdough: 6,000 Years of Bread

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After thousands of years of living together, the real question may be: "who domesticated whom?"

PART 5: STARTER MATURITY MODEL: THE COMPLETE GUIDE

As I worked through the research for this paper, I began noticing patterns and connections across studies that weren't immediately obvious. To make sense of it all, I started building a mental framework to organize what I was learning.

What began as a way to organize my own thinking became a practical guide that I hope will help others navigate the fascinating world of sourdough microbiology. The framework draws on existing sourdough research, including the work of Gänzle and Ripari (2016) on microbial ecology, and others noted in *Appendix L: Sources and References*. The Maturity Model is my proposed synthesis of that research, with some connections and transitions remaining my interpretations rather than directly demonstrated findings.

This guide consists of three tools:

- **The Starter Maturity Map**: A visual guide to help understand how starters transition through the lifecycle of New, Household and Type 1 Starters.

- **Microbial Signposts**: A simplified summary of key microbial "markers" to help identify where your starter resides on the Maturity Map.

- **Signature Species Patterns:** A summary of the typically recurring combinations of yeast and bacteria to help you understand how your starter's unique microbial profile compares to other sourdough starters.

In this section, I take a slightly different approach from the rest of this paper. Rather than simply reporting what the research tells us, I attempt to connect the dots, bridge gaps in the available evidence, and simplify complex scientific concepts into a practical model of sourdough starter maturity.

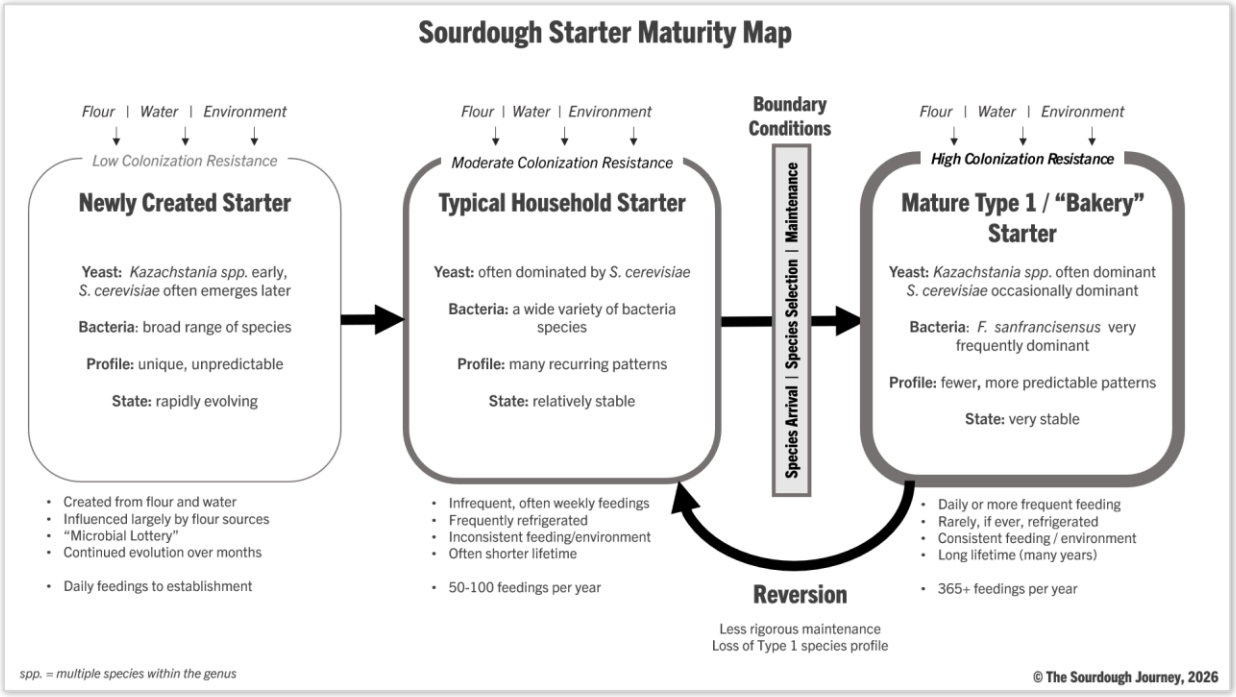
Where the research is incomplete, I draw on the available scientific evidence, my own experiments, and years of experience working with sourdough starters.

The Sourdough Starter Maturity Map

The map describes sourdough starters as occupying one of three broad ecological stages: New, Household, and Type 1/ "Bakery" starters. These are not simply age categories. They reflect the possible paths, stopping off points, and lifecycle of sourdough starters.

The Maturity Map brings those findings together into a single practical framework.

The sections that follow describe the major features of the map at a high level. Supporting evidence, study-specific details, methodological issues, and individual case studies are provided in *Appendix K: The Starter Maturity Map: Supporting Research*.



Three Stages of Starter Maturity

Stage 1: Newly Created Starter

New starters are characterized by microbial chaos. Combining flour and water in a jar kicks off a primordial battle – ancient species of fungi and bacteria awake from dormancy and begin competing for survival and dominance.

The microbes found in the jar largely come from the flour sources. Each bag of flour is like a microbial lottery ticket. Additional organisms can come from water, air, kitchen surfaces and human contact, making the early days of a new starter **unpredictable**.

However, after a few days, new starters begin to follow a pattern. Many environmental microbes burst on the scene early, but are short-lived. They burn out quickly, and acid-producing bacteria begin to stabilize the chemistry of the environment. Acidity generally tames wildness in the microbial world.

As acidity levels rise, yeast cells begin to emerge. *Kazachstania* yeasts can become dominant early in starter development (Taheri et al. 2025).

Over the following days or weeks, the microbial chaos subsides and we see a stable environment of acid-producing bacteria and a few dominant yeast species. As new starters stabilize, *S. cerevisiae* often gains a foothold.

New starters are often functionally capable of raising dough in 10-14 days, but continue evolving over the following weeks and months before achieving a stable microbiome.

See *Appendix D: Newly Created Starters – The Research.*

Stage 2: Typical Household Starter

Newly created starters eventually stabilize and graduate to "Household Starter" status. The vast majority of sourdough starters live in this stage of the Maturity Map.

Household starters are characterized by the realities of maintenance in a non-production bakery environment:

- Less than daily feedings, typically supporting weekly, or less frequent baking
- Frequent refrigeration
- Varied temperatures (i.e., seasonality), feeding ratios, and types of flour

The hallmark of household starters is **diversity**:

- A diverse population where seemingly "every starter is different"
- Microbial diversity in each starter. Multiple species of yeast and bacteria cohabitating.
- Diverse maintenance routines. Refrigeration, feeding ratios, flour types, kitchen temperatures, hydration, etc.

At a microbial level, household starters are typically dominated by one species of yeast, *Saccharomyces cerevisiae* – the species typically found in commercial yeast, brewer's yeast and winemaking. *S. cerevisiae* appears to be a "general purpose" yeast species which adapts to many different environments and microbiomes.

On the bacterial side, there is no dominant bacteria species found across a broad range of household starters. Bacterial diversity is a primary differentiator between Household and Type 1 starters. Most Type 1 starters have a single dominant bacteria species – *F. sanfranciscensis, and* ***that species is uncommon in Household starters.***

Household starters appear to adapt to their maintenance methods and environments.

Stage 3: Type 1 / "Bakery" Starter

Type 1/ "Bakery" Starters are unusual in the world of sourdough starters. Often found in production bakery environments, they have a very narrow and specific microbial profile:

- *Fructilactobacillus sanfranciscensis* provides the strongest bacterial signal,
- *Kazachstania* species, particularly *K. humilis*, are strongly associated with the yeast population. *S. cerevisiae* often occurs with these species.

This class of starter is also defined by its maintenance routine:

- Fed daily or more frequently
- Rarely if ever refrigerated
- Long term, consistent maintenance routine (typically years or decades).

Type 1 starters probably do not emerge simply through a lucky draw in the "new starter lottery." They likely develop from Household starters that traverse a set of specific **boundary conditions**.

The Type 1 Boundary Conditions are:

1. **Arrival**: Type 1 starters are characterized by a distinctive collection of yeast and bacterial species. These organisms must first be introduced into the starter before they can become established.
2. **Selection**: Once the signature Type 1 species find their way into a starter, they need to be "selected" for dominance, likely through many successive generations of feedings, where they need to "outcompete" other established organisms to gain dominance based on the specific maintenance environment (e.g., flour type, feeding ratio, temperature).
3. **Maintenance**: Type 1 starters are also defined by their maintenance protocol which must be continuous to maintain a stable environment – fed daily (or more frequently), rarely if ever refrigerated, and maintained for long periods of time (likely years or decades). Type 1 starters are sometimes old, but are not defined by their age.

Type 1 starters are not spontaneously occurring: they are made by humans. Because they rely on specific human interaction for their creation and maintenance, these can be thought of as "domesticated" starters, similar to the way domesticated dogs evolved from wolves, with human interaction.

Newly created starters are true "wild starters." Household starters are somewhere in between wild and highly domesticated. I consider Household starters to be "human assisted."

Many more questions remain about the creation and maintenance of Type 1 starters. See *Appendix E: Type 1 Starters* for more information on this fascinating topic.

Stage 4: Reversion

The final element of the map is movement back across the Type 1 boundary to Household.

When the intensive maintenance is substantially relaxed or changed, a Type 1 microbial community may begin shifting toward a more typical Household profile. This process is shown on the Maturity Map as **Reversion**.

Reversion does not return a starter to the New Starter stage. It is a transformation of an already mature sourdough microbiome and it may be partial or extensive.

Several published studies and long-term starter case histories provide evidence of Reversions and the loss of characteristic Type 1 organisms under relaxed maintenance conditions.

Reversion is analogous to **domesticated animals becoming feral.** The organisms remain descendants of a human-maintained system, but once the selective pressures of regular Type 1 maintenance are relaxed, the community can shift toward a less tightly controlled ecological state.

See *Appendix F: What Happens When Type 1 Maintenance Stops.*

What about "well-maintained" starters, in a home?

"Well-maintained" is a **maintenance pattern**, not a separate microbiological maturity class. But it raises the question of two "borderline conditions."

1. **Well-maintained Household starter:** Frequently refreshed, rarely or never refrigerated, follows the maintenance pattern of a Type 1 starter, but its DNA still does not show the signature Type 1 pattern (e.g., *F. sanfranciscensis* as the dominant bacteria). This would be characterized as a "Household starter following Type 1-style maintenance."
2. **Home-maintained Type 1 starter:** Similarly, a Type 1 starter does not need to reside in a bakery. A Type 1 starter is defined by its maintenance condition and its species profile, and it can reside anywhere. My starter and the source starter in this study are both examples of Type 1 starters, maintained in a home.

That is an important clarification because **where the starter lives does not define its category**. A home baker can maintain a starter under Type 1-like conditions, but you cannot know from maintenance history alone whether the microbial community has actually crossed that boundary.

Frequent feeding alone does not establish Type 1 status.
Some well-maintained household starters may remain Household; others may develop a Type 1 species profile. DNA analysis is required to distinguish them.

Supporting Research

The Maturity Map is a **simplified framework** for capturing complex microbial states and interactions in a single diagram. It is intended to give sourdough bakers an accessible conceptual model, while remaining grounded in a broad body of scientific research drawn from many disparate studies.

The table below shows the principal studies underlying each part of the map. Readers who want to explore the deeper scientific foundation, including study methods, findings, and how each source informed the framework, see *Appendix K: The Starter Maturity Map: Supporting Research.*

Table 6: Scientific Studies Underlying the Maturity Map

Study	New	Household	Type 1	Reversion
Siragusa (2009)	●			
McKenney et al. (2023)	●	●		
Taheri et al. (2025)	●	●		
Landis et al. (2021)		●		

von Gastrow et al. (2023)	●	●	
Auerbach study	●		●
Michel et al. (2023)		●	●
Pham et al. (2024)		●	●
Wardhana et al. (2026)		●	●
This study (2026)		●	●

Navigating the Maturity Map: The Key Microbial Players

The scientific names in this document can be confusing at first. As I studied the research, I began to see recurring patterns around three important microbial groups:

- *Kazachstania humilis* and related *Kazachstania* species
- *Saccharomyces cerevisiae, and*
- *Fructilactobacillus sanfranciscensis*

These "Big 3" players appear repeatedly in the research, and their presence (or absence) became useful "signposts" in understanding the complex microbial world of sourdough starters.

I also give these organisms informal nicknames to make them easier to recognize and remember.

Meet the "Big 3"

1. *Kazachstania humilis* (and the "*Kazachstania* Brothers")

Kazachstania humilis is a wild yeast species found in sourdough starters around the world. It is especially associated with traditional Type 1 starters. *K. humilis* is the most frequently referenced member of this group. Other commonly occurring species in the *Kazachstania* genus include *K. bulderi, K. servazzii, K. barnettii,* and *K. unispora*. Different members of this genus appear to fill similar ecological roles in different starters. I think of them collectively as the **"*Kazachstania* Brothers."**

Throughout this paper, I use the scientific shorthand **"*Kazachstania* spp."** which simply means **multiple or unspecified species** belonging to the genus *Kazachstania,* but most often refers to one or more of the five "brothers."

2. *Saccharomyces cerevisiae* ("Common Yeast")

S. cerevisiae is the familiar yeast species used for commercial baker's yeast, brewing, and winemaking. It is found in New and Type 1 sourdough starters, but is particularly prevalent in Household starters, where it is the most commonly occurring dominant yeast species. *S. cerevisiae* appears to be a highly compatible and resilient yeast in sourdough starters.

However, the species *S. cerevisiae* contains over 1,000 genetically distinct strains, which can differ substantially in fermentation behavior and other characteristics. While it appears to be "commonly occurring," there may be substantial diversity at the strain level.

3. *Fructilactobacillus sanfranciscensis* ("San Francisco" bacteria, not from San Francisco)

F. sanfranciscensis is a highly sourdough-adapted lactic acid bacterium and one of the most important bacterial species in traditional, mature sourdough starters. It is especially strongly associated with Type 1 / Bakery starters where it often dominates the bacteria domain. It is uncommon in New and Household starters.

Despite its name, *F. sanfranciscensis* is not unique to San Francisco. It was first identified and named through research on San Francisco sourdough, but it has since been found in sourdough starters around the world.

Navigating the Map Using the Microbial Signposts

By understanding where these microbes are more or less likely to appear, and how their patterns change across starter types, we can develop a practical working understanding of the microbial world of sourdough starters and where specific profiles fit on the Maturity Map. The Microbial Signpost table below summarizes these patterns.

Table 7: Microbial Signposts Across the Maturity Map – The "Big 3" © The Sourdough Journey, 2026

	New Starters	Household Starters	Type 1 Starters	Reversion
***YEAST:* *K. humilis* *Other K.* spp.**	**Appears early** in new starters. May be displaced by *S. cerevisiae* with time	**Not typically dominant**. Can persist in some household starters	**Characteristic Type 1 yeast;** well-adapted to the mature sourdough ecosystem	**May decline** in dominance with less rigorous maintenance, or other stressors
YEAST:* *S. cerevisiae	Fast-growing competitor; **may establish early** if conditions favor it	**The most common dominant yeast.** Persists with infrequent feedings and refrigeration	**Can dominate,** but is less characteristic than *Kazachstania* spp.	**May gain dominance** when Type 1 maintenance is relaxed
BACTERIA:* *F. sanfranciscensis	**Uncommon.** Not typically found in measurable quantities in flour	**Uncommon.** Can be dominant and persistent, but dominance is infrequent	**Hallmark bacterium** of mature Type 1 starters; strongly selected by frequent propagation	**Persistent**; may decline or be displaced under substantially altered maintenance conditions

Sources: See Table 6.
Classification note: A Type 1-like microbial fingerprint is characteristic of mature bakery starters but uncommon in household starters. In the Landis "Household" dataset, only 3.8% of starters had both *Kazachstania* spp. and *F. sanfranciscensis* **as the most abundant yeast and bacteria species**, giving this combination useful discriminatory power.

Understanding Signature Species Patterns

We are still in the early days of DNA testing of sourdough starters, but it is easy to imagine a future worldwide, searchable database of starter microbiomes, somewhat like today's ancestry DNA databases, where bakers could compare their starter's microbial fingerprint with similar starters around the world.

In the meantime, I've assembled the following tables from well-documented studies of New, Household, and Type 1 starters as a starting point for comparison.

Note: In this section, "dominant" means the **single species with the highest relative abundance** in each sample, with yeast and bacteria assessed separately. This classification does not use the collective "≥95% abundance rule" used earlier in this document.

See *Appendix I: Commonly Recurring Species Patterns and Co-Occurrence* for additional information and species co-occurrence analysis.

Signature Species Patterns: New Starters

New starters are fundamentally different from mature Household and Type 1 starters. Because their microbial communities are still undergoing rapid succession, they do not have a stable "signature species pattern." Instead, the available studies show a general developmental sequence as the starter moves toward a stable sourdough microbiome. It would also be uncommon to DNA test a New starter, as its microbial profile will likely change as it matures.

Table 8: Observed Succession Patterns in New Starters

Stage	Yeast pattern	Bacterial pattern	Ecological reading
Early	Mixed yeasts and fungi, largely reflecting organisms introduced with flour	Diverse flour- and environment-associated bacteria; many do not persist	Highly unstable initial community; early succession dominates
Developing	*Kazachstania* spp. increasingly prominent and may become dominant	Lactic acid bacteria increase as acidification eliminates less-adapted organisms	Sourdough-selective conditions are becoming established
Late developing	*S. cerevisiae* often increases; *Kazachstania* spp. may persist or decline	More stable, acid-tolerant bacterial community	Approaching a stable sourdough ecosystem and transition toward Household ecology

Source: Taheri; McKenney; Landis
Note: New starters may become functionally usable within roughly 10–14 days, but microbial stabilization continues beyond that point. The New Starter stage ends as the community settles into a comparatively stable Household Starter ecology.
spp. = multiple species within a genus

How to Use the Tables

If you have a DNA report for your starter, compare the dominant yeast and bacteria species from your starter to the matching line items on these tables. This can help you determine whether your starter's microbial profile more closely resembles the Household or Type 1 patterns identified in this study. Once you've identified the closest matching group, you can compare your specific species combination with the more than 500 starter profiles analyzed for this study, and determine if your species profile is common or uncommon relative to this population.

Signature Species Patterns: Household Starters

Table 9: Observed Species Patterns in Mostly Household Starters (Landis n=499)

Rank	Dominant Yeast	Dominant Bacterium	n	%	Cumula-tive %
1	*S. cerevisiae*	*L. brevis*	78	15.6%	15.6%
2	*S. cerevisiae*	*F. sanfranciscensis*	59	11.8%	27.5%
3	*S. cerevisiae*	*L. paralimentarius*	59	11.8%	39.3%
4	*S. cerevisiae*	*Other*	56	11.2%	50.5%
5	*Other yeasts*	*Other*	49	9.8%	60.3%
6	*S. cerevisiae*	*P. parvulus*	49	9.8%	70.1%
7	*S. cerevisiae*	*L. plantarum*	39	7.8%	78.0%
8	*Kazachstania* spp.	*Other, excluding F. sanfranciscensis*	31	6.2%	84.2%
9	*Kazachstania* spp.	*F. sanfranciscensis*	19	3.8%	88.0%
10	*S. cerevisiae*	*L. sakei*	19	3.8%	91.8%
11	*S. cerevisiae*	*L. paracasei*	12	2.4%	94.2%
12	*S. cerevisiae*	*L. rossiae*	11	2.2%	96.4%
13	*S. cerevisiae*	*A. malorum*	10	2.0%	98.4%
14	*S. cerevisiae*	*L. parabrevis*	8	1.6%	100.0%

"Dominant" is the species with the highest relative abundance in each sample. Yeast and bacteria are classified separately.
"Other" categories represent species or species combinations not separately enumerated in the table. "Other yeasts" includes samples whose most abundant yeast species is not individually listed. "Other bacteria" includes samples whose most abundant bacterium is not separately listed for the corresponding yeast category. Individual yeast–bacterium combinations are shown separately when they occur frequently enough to represent meaningful recurring patterns in the dataset.
"n=499" The Landis dataset examined 500 starters. One sample lacked reported abundance data and is excluded here. Source: Landis et al. (2021)

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Observations: Household Starter Signature Species Patterns

S. cerevisiae is clearly the dominant yeast in this mostly-household dataset, occurring as the single dominant yeast species in 80.2% of the 499 starters.

Kazachstania spp., which are much more characteristic of Type 1 starters, were dominant in only 10.0% of the Household starters. Their presence alone, however, does not identify a starter as Type 1. *Kazachstania* species can also occur in developing New starters and in stable Household starters.

F. sanfranciscensis, the bacterial species most strongly associated with Type 1 starters, was the dominant bacterium in only 17.4% of the Household starters.

Among the 59 Landis starters on Row 2 with dominant *S. cerevisiae and F. sanfranciscensis*, 56 (94.9%) had less than 1% detectable *Kazachstania* spp., including 35 with none detected. Although this combination also occurs in mature Type 1 starters, the near-absence of *Kazachstania* in most of these Household samples is noteworthy. These profiles may represent different positions along the proposed maturity continuum, including possible reversion, but their maintenance histories are not known.

Row 9, the combination of *Kazachstania* spp. and *F. sanfranciscensis*, 3.8% of the samples, most closely resembles the signature species pattern commonly found in Type 1 starters. However, these Landis samples were not documented as being maintained under the defining Type 1 protocol of frequent refreshments without refrigeration. This illustrates an important limitation of species-level classification: a microbial fingerprint can strongly resemble a Type 1 profile without, by itself, establishing that the starter is being maintained as a Type 1 starter.

Additional observations:

First, **Household starters are much more diverse on the bacterial side than on the yeast side.** The yeast population is heavily concentrated around *S. cerevisiae*, while that same yeast appears with many different dominant bacteria. That suggests the bacterial community is doing much more of the work in distinguishing one Household starter fingerprint from another.

Second, there is **no single canonical Household species pair**. The most common specific pairing, *S. cerevisiae* + *L. brevis*, represents only 15.6% of the dataset. Even the top six patterns together account for only 70.1%. Household starters are not one microbiological "type;" they occupy a wide ecological middle ground between New and Type 1 starters.

Third, *S. cerevisiae* appears to be **remarkably flexible**. It is paired here with *L. brevis, F. sanfranciscensis, L. paralimentarius, P. parvulus, L. plantarum, L. sakei, L. rossiae, L. paracasei, A. malorum,* and *L. parabrevis*. That is a striking contrast to the much tighter species associations we see in Type 1 starters.

Fourth, the table illustrates the **overlap between New, Household and Type 1 starters rather than hard microbial borders**. The Type 1-associated organisms do occur in Household starters, just at much lower frequencies. So, neither *Kazachstania* nor *F. sanfranciscensis* alone functions as a Type 1 "proof."

Signature Species Patterns: Mature Type 1 / Bakery Starters

Table 10: Observed Species Patterns in Type 1 / Bakery Starters (von Gastrow n=46)

Rank	Yeast pattern	Dominant bacterium	n	%	Cumulative %
1	*Kazachstania* spp. dominant; *S. cerevisiae* <1%	*F. sanfranciscensis*	17	37.0%	37.0%
2	Other yeast pattern	*F. sanfranciscensis*	10	21.7%	58.7%
3	*S. cerevisiae* dominant; *Kazachstania spp.* <1%	*F. sanfranciscensis*	8	17.4%	76.1%
4	*S. cerevisiae* dominant; *Kazachstania spp.* ≥1%	*F. sanfranciscensis*	4	8.7%	84.8%
5	*Kazachstania* spp. dominant; *S. cerevisiae* ≥1%	*F. sanfranciscensis*	3	6.5%	91.3%
6	Various yeast pattern	*Other bacteria*	4	8.7%	100.0%

Note: *Kazachstania* spp. = each *Kazachstania*-dominant sample was dominated by one of the following species: *K. humilis* (8), *K. bulderi* (6), *K. servazzii* (3), *K. barnettii* (2), *Kazachstania* sp.*(2)* or *K. unispora* (1). Other *Kazachstania* species could also be present at lower abundance.

Kazachstania spp. includes multiple species within the genus. "Other yeast pattern" includes alternative dominant yeasts and two samples without a usable yeast classification. "Other bacteria" includes three samples dominated by *C. paralimentarius* and one by *Lactobacillus* sp. In my experiment, my starter profile aligns with Row 4, and the source starter profile aligns with Row 5.

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Observed Species: Mature Starters Type 1 / Bakery

Yeasts from the *Kazachstania* genus frequently dominate mature Type 1 starters. Across this dataset, *Kazachstania* spp. were the dominant yeast in 47.8% of starters, while *S. cerevisiae* was dominant in 30.4%. The two genera also sometimes co-occurred at meaningful abundance, although in some starters one was dominant while the other was detected only at low abundance.

F. sanfranciscensis was overwhelmingly the dominant bacterium occurring in 42 of 46 starters, or 91.3% of the dataset.

Additional Research

See *Appendix I: Commonly Recurring Species Patterns and Co-Occurrence* for more information on this topic.

A New Age of Sourdough Research

The toolkit and guide are provided as the first step in what I hope is a new age of sourdough research, as home bakers around the world now have access to commercially available DNA testing for their sourdough starters.

About the Author

Tom Cucuzza is a sourdough baker and the founder of The Sourdough Journey, an independent sourdough education and research project. His work combines controlled experiments, scientific literature review, and practical baking research to advance the understanding of sourdough and make that knowledge accessible for home bakers. Before focusing on sourdough, he spent three decades in business consulting, implementing transformational programs at some of the world's largest companies. Tom has been published in the Harvard Business Review and other leading publications.

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