The Science of Sourdough!

Provided by HBA Educator Award Winner
Cathe Felz, Family & Consumer Sciences Teacher
Three Forks (MT) Middle & High School

Cross-disciplinary learning and FCS Standards:

Science: ***9.0 Food Science, Dietetics, and Nutrition*** 9.5.3; 9.6.7; 9.7.1, 9.7.7 Understanding fermentation, microbial ecosystems, and the chemistry of bread-making

History: ***12.0 Human Development*** 12.2.5 Exploring global traditions and the cultural significance of sourdough

Culinary Arts: ***8.0 Food Production and Services*** 8.5, 8.7 Practicing measurement, timing, baking techniques, and recipe development

Local Connections/FCCLA: ***1.0 Career, Community and Family Connections*** 1.2.3 Organize and host a Sourdough Showcase and Tasting, where students share their breads and explain the scientific principles. Students may offer sourdough product samples at a senior center or an afterschool site. (Project funding: Montana FCCLA and Youth Service America grants.)

Measurable Objectives

Analyze Historical Evolution of Bread-Making Methods: Students will analyze the historical evolution of sourdough as a bread-making method by creating a timeline or short presentation that highlights key cultural and historical milestones.

Identify Wheat and Flour Types: Students will identify the classes of wheat and types of flours that are most used in sourdough and yeast bread production.

Investigate Fermentation in Food Science: Students will describe the role of fermentation and microbial activity in bread-making by conducting observations of sourdough starter development and presenting scientific findings using appropriate terminology.

Bake, Compare and Contrast Bread Types: Students will compare the characteristics, ingredients, and processes of commercial yeast bread and sourdough bread, demonstrating understanding through written reflection and a visual comparison chart.

Class Period 1

Introduction of Sourdough Terms

The science of sourdough involves the complex biology of wild yeast in flour and the environment that, when mixed with water will ferment slowly and create a mixture used to leaven breads. Sourdough leavens produce a unique texture and flavor.

Microorganisms: Sourdough starters are a living ecosystem of microorganisms, including fungi (yeast) and bacteria. The specific microbes in a starter determine the bread's flavor, aroma, and other characteristics that can be unique to their locale.

Lactic acid bacterium (LAB) is a bacteria that produces lactic and acetic acids, which give sourdough its signature tangy flavor and act as natural preservatives.

Fermentation is the metabolic process where microorganisms break down carbohydrates. Yeast consumes sugars that are introduced by the flour, producing carbon dioxide (CO_2) and alcohol. The carbon dioxide creates air pockets in the bread, making it light and airy.

Symbiotic relationship is a close, long-term interaction between two different species that live together, like yeast and bacteria. The yeast breaks down flour starch into sugars, which the bacteria then feed on. The bacteria can also feed on dead yeast cells.

Starter pH: The pH of a sourdough starter can range from 3-6, and the starter's acidity is influenced by the bacteria.

Starter uniqueness: Every sourdough starter is unique because of the different combinations of microorganisms in the flour used, the water, and the air.

Optimum living conditions: Each strain of microorganism has its own optimum living conditions, such as temperature, water activity, and pH. Sourdough thrives at room temperatures of 70-75˚F.

Flour is a product formed from the milling of grains. The flour used will determine, in part, the available microorganisms for culture. Six classes of wheat flours are grown in the U.S., with the hard wheat flours (red or white) being most often used in sourdough bread production. Whole wheat and unbleached enriched wheat flour are both used. Rye flour is popular in sourdough breads and provides unique culture, flavors and textures.

Gluten forms when water is mixed with wheat flour and is formed from two proteins: *glutenin* and *gliadin*. It acts as a binder, and provides elasticity and structure to baked goods.

Water: Sourdough cultures will develop in water containing minerals, but chlorination retards it. Chlorine can be removed at least partially through evaporation (let water sit out overnight), boiling, stirring and carbon filtration, if time is allowed for any of these processes.

Investigate Yeast Fermentation

Discuss How Yeast and Bacteria Work Together

- Bacteria are much smaller than yeast and outnumber them **100 to 1** in most sourdough cultures.
- *Candida milleri* yeast cannot digest **maltose**, but the bacteria can—reducing competition for food.
- Both organisms consume **glucose**, maintaining balance in the culture.
- The bacteria produce **lactic acid**, **acetic acid**, and **cycloheximide**, a natural antibiotic that kills competing or harmful microorganisms but leaves the symbiotic yeasts and bacteria unharmed
- Identify sensory attributes the microorganisms in sourdough provide in products that are different from commercial yeast products. *(A: tangy flavor and unique texture of sourdough bread)*

Begin Sourdough Starters (day 1)

- See steps on the next page

Make Your Own Sourdough Starter

Makes 4 cups

Ingredients

- All-purpose unbleached flour (or a mix of all-purpose and whole grain flour, like whole wheat or rye)
- Water – use unchlorinated water that contains minerals (starter microbes do not thrive in chlorinated water but DO like minerals)

Equipment

- 1-quart glass or plastic container (not metal) for starter
- 1 qt (24 oz) sealable discard container (See ***Day 5 and Beyond*** #2)
- Scale (highly recommended) or liquid and dry measuring cups
- Food thermometer
- Mixing spoon
- Plastic wrap OR cheese cloth (doubled) OR lid that is not sealed OR non-terry clean kitchen towel

TIP: Pick a time of day to dedicate 5-10 minutes to your starter

Instructions

Making sourdough starter takes about 5 days, but it can take longer depending on the conditions in your kitchen. Each day you "feed" the starter with equal amounts of fresh flour and water. As the wild yeast grows stronger, the starter will become more frothy and sour-smelling. As long as you see bubbles and signs of yeast activity, continue feeding it regularly. If you see zero signs of bubbles after three days, take a look at the Troubleshooting section below.

Day 1: Make the Initial Starter

2 oz (55g) unbleached all-purpose flour
2 oz (55g) 85-90˚F water

1. Weigh and combine the flour and water in the 1-quart glass or plastic container. Stir vigorously until combined into a smooth batter. It will look like a sticky, thick dough. Scrape down the sides and loosely cover the container with plastic, waxed paper wrap, or cheese cloth secured with a rubber band. A lid may be set loosely on top, but air must be able to escape.
2. Place the container somewhere with a consistent room temperature of 70°F to 75°F (like the top of the refrigerator) and let sit for 24 hours.

Day 2: Feed the Starter (You will always feed the starter with a 1:1 ratio flour and water)

You may see a few small bubbles in your starter. This is good! It means the wild yeast have started eating the sugars in the flour and releasing carbon dioxide (CO_2) and alcohol. The bubbles will also increase the acidity of the mixture, which helps fend off any bad bacteria. At this point, the starter should smell fresh, mildly sweet, and yeasty.

If you don't see any bubbles yet, don't panic — your starter might just be slow to get going.

1. **Remove 2 oz starter** from jar and discard. Once your starter is established and healthy with bubbles, the discard can be used for a variety of recipes such as cracker, cookies or buns.
2. **Add 2 oz (55g) flour and 2 oz (55g) 85-90˚F water** to the starter. Stir vigorously until combined into a smooth batter. It will look like a sticky, thick dough. Scrape down the sides and loosely cover the container. Place container at a consistent room temperature of 70°F to 75°F for 24 hours.

Day 3: Feed the Starter

By now, the starter will be dotted with bubbles and visibly larger in volume. If you stir the starter, it will still feel thick and batter-like, but you'll hear bubbles popping. It should also start smelling a little sour and yeasty. Again, if your starter doesn't look quite like mine in the photo, don't worry. Give it a few more days. My starter happened to be particularly vigorous!

1. **Remove 2 oz starter** from jar and discard.
2. **Add 2 oz (55g) flour and 2 oz (55g) 85-90˚F water** to the starter. Repeat stirring, scraping down, and loosely covering. Place container at a consistent room temperature of 70°F to 75°F for 24 hours.

Day 4: Feed the Starter

The starter should be looking very bubbly with large and small bubbles, and doubled in volume. If you stir the starter, it will feel looser than yesterday, be honeycombed with bubbles and smell sour and pungent.

1. **Remove 2 oz starter** from jar and discard.
2. **Add 2 oz (55g) flour and 2 oz (55g) 85-90˚F water** to the starter. Repeat stirring, scraping down, and loosely covering. Place container at a consistent room temperature of 70°F to 75°F for 24 hours.

Day 5: Starter Should Be Ready to Use

The starter should have doubled in bulk since yesterday. It should also be looking very bubbly, even frothy. If you stir the starter, it will feel looser than yesterday and be completely webbed with bubbles. It should also be smelling quite sour and pungent.

If everything is looking good, **your starter is ripe and ready to use**! If your starter is lagging behind a bit, continue on with the **Day 5 and Beyond** instructions.

Day 5 and Beyond: Maintaining Your Starter

Once your starter is ripe (or even if it's not quite ripe yet), you no longer need to bulk it up, but rather maintain it.

1. Use or discard about half of the starter.
   Feed starter with a 1:1 flour to water ratio that is equal to the amount you removed and discarded *(Ex: If you removed 4 oz (110g) starter, feed with 2 oz (55g) flour and 2 oz (55g) water)*. Stir vigorously until combined into a smooth batter.
2. Once starter is re-fed: If using the starter within the next few days, leave it on the counter and continue <u>discarding half</u> (this discard can now be saved in a separate jar and used for discard recipes) and feeding it daily. If it will be longer before you use your starter, cover it tightly and place it in the fridge. Take it out and <u>feed it at least once a week</u>. I also usually let the starter sit out overnight to give the yeast time to recuperate before putting it back in the fridge.

How to Reduce the Amount of Starter

Maybe you don't need all the starter we've made here on an ongoing basis. That's fine! Discard half the starter as usual, but feed it with half the amount of flour and water. Continue until you have whatever amount of starter works for your baking habits.

How to Take a Long Break from Your Starter

Taking a break from baking, but want to keep your starter? Visit **thekitchn.com/take-a-break-from-sourdough-starter-23048268**

Class Period 2

Analyze Historical Evolution

- Using the timeline, dicuss three periods in history especially known for sourdough development. *(A: Egypt, 3500 years ago, California and Alaska Gold Rush, 250 years ago and 2020, the resurgence of interest by home bakers during the COVID-19 pandemic)*
- Discuss why sourdough cultures and products remain an essential staple in today's culture and foods around the world, and note three key ingredients that differ and make the sourdough unique. *(A: flavor, crust; yeast cultures, water, flours)*

Sourdough Timeline

Sourdough starter has a rich history. This natural fermentation was essential to bread baking for most of human history.

4500 BCE	Egyptian bakers observed bread dough mixture became "lighter" over time; Greeks and Romans adopted Egyptian baking and it spread to Europe
3700 BCE	A 5700-year-old loaf of sourdough bread was excavated in Switzerland in 1976
500-1500	Sourdough leavening was the standard way to bake rye and wheat flour breads in Medieval Europe; each region developed it's own unique flavors, and starters were kept alive for generations
1500-1800	Sourdough leavens were carried to new colonies and were essential to baking
1848-1855	Miners and settlers carried and protected starters to bake bread in remote places during the California and Alaska gold rushes
1876-1900	Commercial dry yeasts were developed and became popular. See a diagram of yeast production!
1990-2026	Sourdough and long fermentation baking becomes popular again for its deeper flavors, crusts and regional or local appeal

Identify Wheat Classes and Flour Types

Image from homebaking.org/wp-content/uploads/2023/06/2020-Wheat-101-One-Pager-1.pdf

Identify your local wheat classes and flour sources from the map at **National Association of Wheat Growers**.

Visit **Wheat 101** at the National Association of Wheat Growers and watch the 20 minute film if time allows. Learn more about how flour is milled at **NAMA Millers**. Invite a wheat producer or miller to share about their career from your area to your class.

Compare Yeast & Sourdough Breads

Both methods create delicious bread, but each offers unique benefits.

Similarities Between Yeast Dough and Sourdough

- **Ingredients**: Both require flour, water, and salt.
- **Fermentation:** In both, fermentation produces carbon dioxide (CO_2) to make the dough rise. Both sourdough and yeast can produce long fermentation artisan breads.
- **Kneading**: Both types of dough can involve kneading or mixing with a dough hook to develop gluten for structure and elasticity.
- **Proofing**: Both require a final rise (proof) before baking to allow the dough to expand.
- **Baking Process**: Both are baked in ovens, and the result depends on steam to develop a good crust.

Differences Between Yeast Dough and Sourdough

- **Fermentation:**
  - In yeast bread, commercial yeast (*Saccharomyces cerevisiae*) is hydrated with water in a dough mixture, and will quickly ferment and produce CO_2 for leavening. *(Explore the history of commercial yeast at **redstaryeast.com/science-of-yeast**.)*
  - In sourdough, a natural culture of wild yeast (*Saccharomyces exiguus*) and lactic acid bacteria (*Lactobacillus spp.*) create a slower fermentation. Wild yeast ferments sugars, producing CO_2 and alcohol, while bacteria create lactic and acetic acids for tangy flavor and preservation.
- **Time & Care**:
  - Yeast dough is faster, more predictable, and has a mild flavor. It relies on commercial yeast, which ferments quickly, ideal when time is limited.
  - Sourdough requires more time and care, as the wild yeast and bacteria need longer to ferment. The result is a more flavorful bread with better shelf life, a chewy texture, and a deeper, artisinal experience.
- **Shelf Life**:
  - Yeast bread (made without preservatives) has a short shelf life.
  - Sourdough bread lasts longer because the natural acidity inhibits mold and bacteria growth.

Demonstration: Compare commercial yeast fermentation with sourdough fermentation, and the breads produced from each

Materials needed:

- For commercial yeast mixture
  - 1 qt liquid measuring cup
  - 1 pkg (7g) active dry yeast
  - 4 oz (115g) or 1/2 cup 85˚F water
  - 4 oz (115g) flour
- Jar with a sourdough culture, 3-5 days old
- Microscopes
- Loaves of commercial or home-baked yeast bread and sourdough bread

- **Demonstrate:** Prepare the commercial yeast mixture and allow to stand 30 minutes. Show a side-by-side comparison of the yeast mixture and the Day 3-5 sourdough starter. Discuss the length of time to develop gas and bubbles.
- **Microscopes:** Students prepare slides and observe commercial yeast and sourdough starter under a microscope, noting differences in structure and diversity of microorganisms.
- **Sample:** Slice and provide samples of both yeast and sourdough breads. Discuss similarities and differences.

Discussion

- Predict what will happen to their sourdough starter.
- Discuss and "visit" real-world applications.
- Assign/explore websites in the Baking Careers Guide found at HomeBaking.org. Visit HomeBaking.org/members, HomeBaking.org/Partners, futureinbaking.com, and ASBE.org to learn more about careers.

Critical Thinking Discussions

- Explore the intersection of science, history, and food by hands-on sourdough cultivation and baking.
- What are 5 key ingredients and their functions in yeast breads? *(A: water, flour, heat, salt, yeast)*
- What microorganisms are essential in cultivating sourdough starter and where are they found? *(A: wild yeast and lactic bacteria; in flour, air)*
- What types of wheat flour are most used in sourdough bread and why? Do you grow one of these classes near you? *(A: Hard wheat flours- all-purpose from hard wheat regions; bread flour; hard red and white wheat classes; whole wheat, and unbleached enriched flour all may be used)*
- What can you observe with microscopes about the activity of living sourdough cultures; what changes did you measure and sensory changes did you note in a fermented sourdough starter over 5 days?

Photos from BiggerBolderBaking.com

Class Period 3

Understanding Gluten

Discuss gluten and why it is important.

- Gluten forms when water and flour are mixed. The proteins in flour vary, but the proteins *glutenin* and *gliadin* are the two essential components in flour for forming gluten.
- Hard wheat flours (bread and higher protein all-purpose) have the best potential to form gluten for bread baking.
- Gluten is essential in bread baking because it acts like tiny, invisible balloons that trap carbon dioxide, creating the chewy structure we expect in bread.
- Gluten can be developed:
  - By mixing and kneading (mechanical development), often used for faster bread baking.
  - Through longer fermentations such as sourdough or long fermentation breads using commercial yeast.
    - During fermentation, the dough will rise or expand for several hours—or even overnight—allowing gluten and flavor to develop. Sourdough and long fermentation breads support gut health because they contain beneficial bacteria, and no added gluten is typically needed for machinability.
- Check out this guide: homebaking.org/flour-101-a-guide-for-baking-educators
- In ***A Baker's Dozen Lab Manual***, Lab 3, Conduct the "Flour is NOT Just Flour" experiment.
  - Scale in separate cups 2 oz amounts of all-purpose, bread, cake and pastry flours. Add 2 oz water to each and stir each equally for 1 minute, then compare the gluten development and absorption. Watch demonstration video here: youtube.com/watch?v=X4lZwrYvjQk

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Bake a Loaf of Sourdough Bread

When the sourdough starter is ready, it's time to bake! Select a recipe below or search "sourdough baking" at HomeBaking.org. For each recipe, identify the steps for ***Baking Food Safety and Handling*** (homebaking.org/baking-food-safety) in preparing the dough, cooling and handling the baked product.

- **Beginning Sourdough Bread** biggerbolderbaking.com/sourdough-bread-for-beginners
- **Focaccia** bakerbettie.com/easy-sourdough-focaccia-bread
- **Basic Sourdough Bread (pan loaf)** kingarthurbaking.com/recipes/basic-sourdough-bread-recipe
- **Sourdough Bread Loaf** thekitchn.com/how-to-make-sourdough-bread-224367
- Combine the best of sourdough and yeast! Try **Soft Sourdough Rolls**, redstaryeast.com/recipes/soft-sourdough-rolls
- **Whole Wheat Sourdough Bread** kingarthurbaking.com/recipes/whole-wheat-sourdough-bread-recipe

HBA Members and Partners are a career and ingredient resource connection: homebaking.org/members

Glossary for guides to all baking ingredients homebaking.org/glossary

Infographics *including* ***Wheat 101, Flour 101, Diagram of Yeast Production, What Happened to My Yeast Bread?*** *and* ***What is Gluten?*** *can be found at* homebaking.org/infographics