Carol B Kenney, Ph.D.
The Science of Natural Health

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Spring 2015: Sourdough Culture: History, Health Benefits, "How To" and Science Why's

Baking with sourdough has a long history, which dates back to the early Egyptians some 5,000 years ago. The Egyptians discovered that if they mixed and kneaded flour and water together and left it in a cool place, dough would magically rise to create pleasant-tasting, easy-to-work dough for leavened bread.

While the ancient Egyptians did not understand the complex and fascinating science behind a dependable, long-lasting sourdough culture—a "culture" that involves healthy yeast and bacteria living in symbiotic and sustainable harmony—what they did grasp was that by adding a bit of reserve from a "good" batch of dough to a fresh mix of flour and water before kneading, they could speed the fermentation of the new dough and insure that bad bacteria in the environment did not get the upper hand. Without knowing the underlying science, but with this simple discovery, "starter" was born.

Bread baking as perfected by the Egyptians carried forward for centuries as village bakers and homemakers throughout much of the world used sourdough to leaven bread. They developed a "feel" for dough and an appreciation not only for the way sourdough contributes complex taste, nuance, texture and elasticity to a simple mixture of flour and water, but also for the way it could retard mold and spoilage.

Unfortunately, in modern times with the discovery of bakers yeast in the 1870s and the commercial development of "factory bread," the art of sourdough baking has largely been lost. With this lost art have also gone the many health, nutrition, and taste benefits that sourdough starter contributes to baked goods:

> *Sourdough culture works on whole-grain flour both to moderate its blood sugar effect and its phytates. Sourdough's ability to diffuse phytates means that vital minerals such as calcium, magnesium, iron, copper, and zinc contained in the bran of whole grains are freed and available for the body to utilize.*
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> *Sourdough enhances the nutrition and enzymes in whole grains.* Sourdough fermentation, like yogurt fermentation, creates new nutrients—bacteria synthesize vitamins such as B_{12}; meanwhile, yeast boosts lysine, the limiting amino acid in grains, to help make sourdough bread a nearly complete protein.
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> *Sourdough adds a richness and depth of flavor to baked goods, while it contributes strength and elasticity to dough to make kneading easier and the addition of bakers yeast unnecessary.*

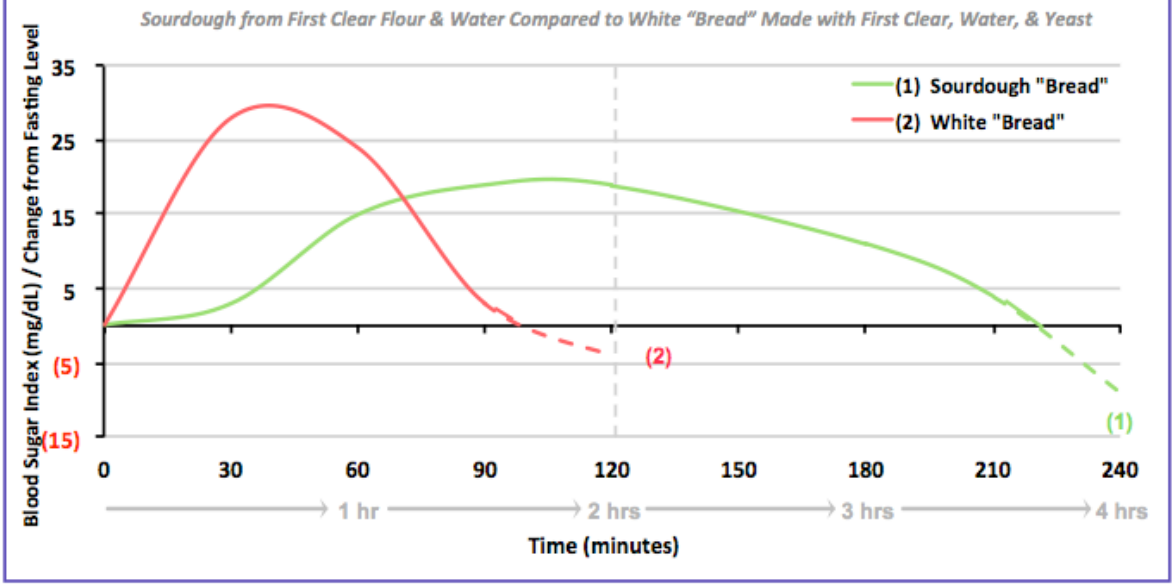
[Bakers yeast should not be added to a sourdough cultured during fermentation because it competes with lactobacilli (the main healthy bacteria in sourdough) for the same food, maltose.]

Sourdough culture is a "pre-ferment." Growing a culture the day before preparing baked goods gives any bakery product a "jump start" on flavor, texture, and elasticity. And, adding sourdough to the dry ingredients of bakery recipes and allowing the contents to soak overnight is an effective way to lower the glycemic impact and phytates in whole-grain bakery products.

Health Benefits of Sourdough Lost in the Shift to Bakers Yeast and Dwarf Wheat

Sourdough fermentation moderates the blood sugar effect of baked goods as bacteria convert the sugars in flour to lactic and acetic acids, which digest slowly and which the body retains in the digestive system for a long period of time, to help moderate blood sugar reactions. Meanwhile, yeast convert sugars to ethanol (which burns off in baking) and carbon dioxide. In addition, sourdough fermentation limits the extent to which starches are broken down (gelatinized), something that also moderates the glycemic impact of bakery products.

Chart 1: The Power of Sourdough to Curb Metabolic Stress and Sustain Blood Sugar



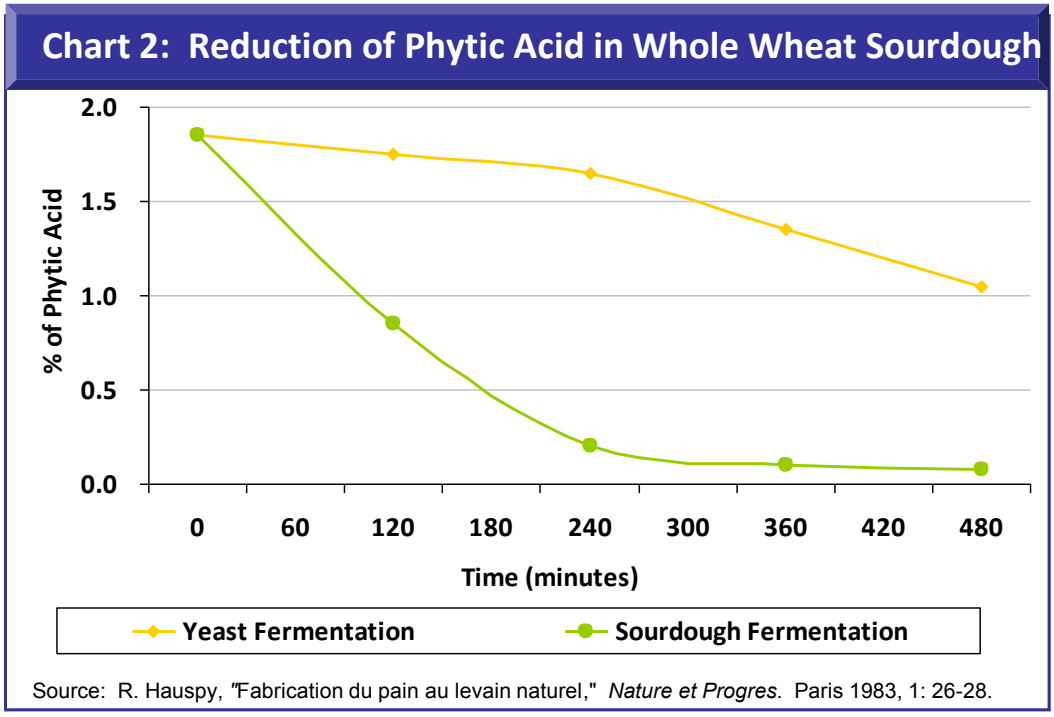
Source: Pathways4Health.org
1) 2 oz. Baked Sourdough Starter made with First Clear and Water
2) 2 oz. "Bread" made with First Clear Flour, Water and Yeast

You might try your own sourdough blood sugar experiment with a blood glucose monitor (Chart 1). To test the power of sourdough, I combined white flour and water in two separate batches, one that was baked straight away, and the other with the addition of sourdough that fermented overnight. On two

separate mornings, I ate these as a first meal after fasting overnight and then tested my blood sugar every 30 minutes until my blood sugar dropped below the pre-meal fasting level. "White Bread without Sourdough" made my blood sugar spike at a level more than twice that of the sourdough batch and (due to the insulin response) it quickly fell back again. In contrast, there was no spike with "White Bread with Sourdough"…my blood sugar rose slowly, smoothly, and gradually. It peaked and leveled off between 90 and 120 minutes at a reading of 19, less than half White Bread's peak. As indicated, my blood sugar was sustained above its starting point for almost four hours, twice as long as for White Bread.

While this is just one home-kitchen experiment, the results are supported by repeated scientific studies: White bread made with bakers yeast metabolizes rapidly, even more rapidly than sugar, hence spiking blood sugar. In contrast, sourdough bread has a modest effect on blood sugar, tracing a smooth curve that is roughly equivalent to the body's modest response to eating whole grains, beans, and legumes.

Sourdough fermentation boosts nutrition. During proofing, yeasts in sourdough boost lysine, the limiting amino acid in grains, to help make sourdough bread a nearly complete protein. In addition, long proofing allows lactobacilli time to neutralize phytic acid (Chart 2), a natural protection found in the bran of whole grains which would otherwise block digestive enzymes (pepsin, amylase, and trypsin) and the absorption of the vital minerals found in grains such as potassium, phosphorus, calcium, magnesium, iron, copper and zinc. Sourdough bacteria, as in yogurt, also synthesize vitamins, especially vitamin B_{12}.



Gluten Issues…and Sourdough. Gluten intolerance is a growing problem today, and it is something that is deeply rooted in factors too powerful for sourdough alone (with the strains known to science today) to be able to resolve.

Gluten intolerance is primarily related to the generally poor gut health of our population, which is something fostered by our modern diet of refined, processed, low-fiber foods, as well as to our dietary reliance on wheat, which is higher in gluten than other grains. To make matters worse, the problem of wheat as our mainstay grain is compounded by our recent shift to a high-yield type of hybrid, extremely high-gluten wheat, called "dwarf wheat," that was developed by scientists in the 1970s.

Compared to heirloom wheat like einkorn and emmer, which are simple (Table 1), relatively low-gluten wheat varieties that date back centuries, dwarf wheat that was developed in the 1970s has an extra set of chromosomes, something that lies outside our evolutionary norm. Historically, sourdough has been able to at least partially break down the less-resistant gluten in heirloom wheat by inserting extra water molecules into gluten strands so that they are better tolerated by people with gluten sensitivities. This is not the case with the gluten in dwarf wheat, which is highly resistant and breaks down very slowly.

Table 1: Genome of Wheat[1]

Wheat	Species	Type	Genome	#Chromosomes
Einkorn	Triticum monococcum	Diploid	AA	14
Emmer	Triticum turgidum, dicoccum	Tetraploid	AABB	28
Dwarf	Triticum aestivum	Hexaploid	AABBDD	42

Scientists are working to develop strains of sourdough bacteria to more effectively breakdown gluten, but, even if they are successful, it is hard to imagine that commercial bakers would be willing to incorporate sourdough, with its need for long fermentation time, into their factory process. I suspect the overarching problems of our generally poor diet and gut health, as well as our reliance on high-gluten dwarf wheat and the commercial use of bakers yeast suggest that even new, yet undiscovered strains of sourdough cannot be counted on to overcome these broader issues. The easy remedy is to take up home baking with sourdough, since we **can** buy heirloom grains through such sources as Anson Mills and we **can** grow and maintain sourdough culture in our home kitchen to create healthy baked goods that incorporate the many health benefits of sourdough.

The balance of this newsletter explains how to keep a healthy sourdough culture in your home kitchen. Also included as a separate piece are some easy recipes for using sourdough, as well as ideas for how to

[1] Derived from Stallkneckht, Gilbertson, and Ranney,

incorporate sourdough in some of your favorite recipes. In a subsequent newsletter, we will describe the slightly more complicated process of how to make sourdough bread with heirloom flour, something that requires three days to let sourdough work its magic, but something that is well worth the effort.

"Why not purchase sourdough bread over the counter?" Because most sourdough loaves sold commercially are doctored with vinegar and other flavorings to make them taste like sourdough, without the health benefits. It is not efficient or economical for commercial bakers to allow the time required to produce a true loaf of sourdough bread.

How to Feed and Maintain A Sourdough Culture

Equipment You Will Need:

- Large wide-mouth Ball jar with lid; 1- or 2-quart size
- Sourdough culture; either ¼ or ½ cup, available from King Arthur
- King Arthur First Clear flour. First Clear is a high-ash variety that promotes fermentation and the building of flavor by controlling pH levels.
- Set of measuring cups
- Long-handled wooden spoon for stirring; spatula for scraping spoon after each addition.
- Proofer (optional) is helpful in cold weather to speed the three feedings

Directions: for Creating Enough Sourdough Culture to Make One or Two Loaves of Bread

(Use ¼ cup starter if you need only a small amount to add to your favorite recipes.)

1 Qt Jar; ¼ Cup Starter; Yield ~2 Cups Starter		**Flour**	**Water**		**2-Qt Jar; ½ Cup Starter; Yield ~3-4 Cups Starter**	**Flour**	**Water**
Jar	1 Qt.				2 Qt.		
Starter	1/4 Cup				**½ cup**		
Feedings:							
1st		1/8 Cup	1/8 Cup			¼ Cup	**¼ cup**
2nd		¼ Cup	¼ Cup			½ Cup	**½ cup**
3rd		½ Cup	½ Cup			1 Cup	**1 cup**
Yield	**~ 2 Cups**				**~3-4 Cups**		

- Keeping "safety" starter in reserve in your refrigerator. If you are feeding starter from prior baking adventures, pour off into a jar any excess that you have that exceeds the amount given above and keep this as a backup in the refrigerator so you always have viable starter should anything happen to the starter that you are currently feeding. You can discard any old reserve starter that you have saved in the refrigerator and replace this with the fresh reserve starter every time you feed starter again.

- Progressive incremental feeding: Whatever amount of starter at the outset, in order to maintain a healthy balance of good yeast and bacteria, a general rule is to feed your culture in three progressive intervals… first, *half*; then, *equal*, and finally, *double* the amount of flour and water *relative to the amount of initial starter*. You do not want to overwhelm the culture at the outset with too much flour before giving the yeast and bacteria enough time to multiply. Too much flour can encourage foreign invaders (bad bacteria) to grow and spoil your culture.[2] A small feeding at first gives the yeast and bacteria time to populate the culture to then be able to handle progressively larger amounts of flour and water.

- Feedings: To maintain a vibrant culture, it is best to feed it and use it once or twice a week. A culture, very much like people, is happiest and healthiest when it is fed, exercised, and then allowed to rest (in the refrigerator) on a regular basis. When you are ready to feed your starter and have taken it from the refrigerator and poured off a reserve, first allow it to warm it up. Then, by feeding, stirring, and exposing it to air, you will encourage it come to life. The purpose of three feedings is to fully awaken starter from its dormant, refrigerated state. You will see that with successive feedings, as the starter warms and becomes more active, it will double in size more rapidly: Doubling after the third feeding will happen faster than after the first and second.

- Time and Temperature: The time required to feed starter three times to reach a peak at the top of a Ball jar can take anywhere between 6 to 12 hours, depending on room temperature; the temperature of your starter, flour, and water; how often you use your starter; and the type of yeast in your culture (some yeast rise more rapidly than others). Feeding starter works best at temperatures between 65^{o} and $80^{o.}$ In cold weather, if you have a proofer, a setting of ~80^{0} will work well. Heat above 95^{o} can kill yeasts, so avoid extremely high temperatures.

- First and successive feedings: Add the flour and water and stir vigorously to "exercise" your starter and incorporate oxygen. Yeasts use oxygen to create carbon dioxide (bubbles that will help dough rise). Scrape down the sides of the Ball jar. (This will allow you to keep track of the starter as it grows up the jar, see when it has doubled in size, and know when it needs to be fed again). Replace the lid. Covering the jar with a lid allows fermentation to take place in its normal two stages, respiration and fermentation. In the "respiration" phase before available oxygen is exhausted, yeast converts sugars in flour to carbon dioxide; then in the "fermentation" phase without oxygen sugars are changed to alcohols (the flavorings). Set the jar on the counter (or proofer) and allow the starter to double in size, which it will do as yeast and bacteria multiply.

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[2] **A Ball jar of starter, window to our gut?** I believe there is a parallel between the concept of overfeeding a sourdough culture and the subsequent growth of "bad" bacteria and the way we overfeed ourselves with processed foods to cause the modern "leaky-gut syndrome." Isn't overfeeding a starter with too much flour similar to what we do to ourselves when we ingest large quantities of sugar, high fructose corn syrup, and refined flour products? These types of calories that characterize the Standard American Diet lie outside our evolutionary norm, and they "crowd out" traditional foods from our heritage—high-fiber fruits, vegetables, and whole grains—often allowing bad bacteria in our gut to seize control, resulting in "leaky gut" and a host of other ills—from behavioral issues to allergies and even autism (see *Gut and Psychology Syndrome* by Natasha Campbell-McBride, MD)

- When to feed starter again: If you forget to feed a culture once it has doubled in size, it will fall back, losing volume. This is a sign that the yeast has run out of food and needs to be fed again. Yeast work more rapidly than bacteria so a culture will reach its full volume before the bacteria have completed their work converting maltose to flavor compounds. Once starter has doubled three times to reach its maximum volume (it will crest at the top of the "Ball" label on the jar), put the starter in the refrigerator to be used the next day, or even a second day (less "lift" but even more flavor, since bacteria will continue to create flavor). Alternatively, if your goal is to maximize leavening rather than flavor, you can use starter at the moment that it peaks on the first day after the third rise. Yeast will at this time be most active and provide the most leavening to dough.

For a vibrant culture, feed and use it often. Once you have a starter, you want to keep it fed and working for you. A starter that is fed often is "happy" and active. After a week in the refrigerator, yeast and bacteria run low on food; some have died. I like to keep my starter active by feeding and using it at least once a week. Starter can be kept for up to three weeks in the refrigerator, but it may require several feedings to bring it fully back to life.

Starter is unique, a product of your local environment.. Keeping sourdough starter and using it in everyday baking is the epitome of living local. This is true even though a Martha's Vineyard starter, like one grown in Chicago or San Francisco, starts out exactly the same, as a mixture of flour and water. With successive feedings, each is transformed by the unique set of wild yeasts and bacteria in the local environment as these feed on the starch energy in the flour. Shipping a San Francisco culture to the East Coast to replicate the wonderful sourdoughs of the Bay Area would not be viable, since it would soon be overtaken by the microscopic wild life of your local area. Also, because cultures differ by region, their behavior and taste vary: some rise more rapidly than others, and each has its own coloration of sour, yeasty aroma, and flavoring complexities.

Sourdough cultures, once they become stable, can last for years, even centuries. Healthy sourdough cultures are each a unique combination of wild yeast and bacteria from the local environment that live symbiotically to support each other. Most cultures contain yeast and bacteria (largely lactobacilli) in a ratio of about 1:100 (considered ideal) and they support each other since they do not compete for the same foods. Yeasts are much larger than bacteria. Most sourdough cultures have one strain of yeast and as many as four types of bacteria. Yeasts vary in terms of fermenting time; those that react quickly leave less time for bacteria to develop acids and flavorings, resulting in a milder, less-complex tasting culture.

Yeasts eat the simple sugars, fructose and glucose, found in flour but they cannot digest maltose, which is the essential food of lactobacilli. Lactobacilli thrive on maltose and set free a glucose molecule, which conveniently feeds yeast; meanwhile yeast discards compounds that support the growth of lactobacilli. In addition, when lactobacilli eat maltose and produce acids, mostly lactic acid and some acetic acid, they lower the pH of a culture to 4-4.5. Sourdough yeasts grow best in acidic environments and this acidic environment helps protect the ecosystem from foreign invaders like botulism and E. coli bacteria.

Bakers Yeast: Scientists learned to cultivate bakers yeast for commercial use in the 1870s, which gave rise to factory bread as we know it today. Bakers yeast is genetically engineered for the quick creation of carbon dioxide gas to make dough rise rapidly but without the benefit of sourdough's complex tastes, texture, and natural preservatives. *Air, no taste.* Without sourdough's lactobacilli, commercial bread bakers must add back artificial flavors, conditioners, and preservatives. Unlike sourdough yeasts, bakers yeast grows best in a neutral to alkaline environment.

Since bakers yeast and lactobacilli both eat maltose and compete for the same food, adding bakers yeast to a sourdough culture will spoil the culture. *Never add anything but flour and water to a sourdough culture.* Sourdough cultures vary by locality and can be grown again and again, in contrast to bakers yeast, a hybrid monoculture product without complexity or nuance that expends with one use.

Fermentation—Texture and Taste: When feeding starter and before replacing the lid, vigorously stir in flour and water not only to feed yeast and bacteria, but also to incorporate oxygen. With oxygen (aerobic fermentation), yeasts convert sugars to carbon dioxide to leaven dough. Then, when the oxygen supply is exhausted (anaerobic fermentation), yeasts switch over to produce alcohols (these largely evaporate during baking) as well as the amino acid glutamate (the savory umami flavor). To allow for both stages of fermentation in order to develop both CO_2 and flavor, stir starter vigorously at each feeding and then cover the jar to encourage both stages of yeast fermentation.

The sour flavor associated with sourdough comes from lactobacilli, the major bacteria in a sourdough culture. Lactobacilli convert maltose to mild acids, particularly lactic and acetic acids, which give sourdough its sour flavor. Lactobacilli and other bacteria in the culture also produce ethanol (alcohol) from which multiple flavors develop through secondary chemical reactions.

> *Hooch.* After a starter sits for a while without oxygen in the refrigerator, it develops a layer of brownish liquid on the surface, called "hooch," which is composed of alcohol and bacteria flavoring compounds. Stir it back in if you like a stronger flavor for your baked goods, or pour it off if you prefer a culture that is milder in flavor.

Soaking ingredients with sourdough helps moderate their blood sugar effect. Scientific research suggests three main reasons, all associated with fermentation, why sourdough reduces the metabolic response to grains: (1) The major by-product of fermentation is lactic acid, which slows the rate at which the body digests starch; (2) Acetic acid, a lesser by-product from fermentation, results in the body retaining food in the digestive system for a longer period of time; and (3) Chemical changes to grain carbohydrates during sourdough fermentation limit the degree to which starches are gelatinized (gelatinization of grains and starches works to spike blood sugar because it allows for a faster digestion and assimilation). As mentioned earlier, while bread made with bakers yeast and white flour metabolize even more rapidly than sugar, sourdough bread made with whole grain flour has a modest glycemic effect on the body, one equivalent to whole grains, beans, and legumes.

Reading Resources:

Emily Buehler, *Bread Science*
Karel Kulp and Klaus Lorenz, *Handbook of Dough Fermentations.*
Sara Pitzer, *Baking with Sourdough*
Lisa Rayner, *Wild Bread*
Daniel Wing and Alan Scott, *The Bread Builders: Hearth Loaves and Masonry Ovens*
Ed and Jean Wood, *Classic Sourdoughs: A Home Baker's Handbook*

www.ellensfoodandsoul.com
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July/August 2011: *Phytic Acid and Health*
September/October 2012: *Defending Traditional Grains*
November/December 2012: *Reviving Culture and the Health Benefits of Sourdough*
September/October 2013*: Living With and Experimenting With Sourdough*