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Vegetable Fermentation

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Editors note: This publication contains the video of the talk from the Fermentology webinar series, as well as a lightly edited transcript of the lecture.

Abstract

In many parts of the world, especially in regions with limited growing seasons and long winters, people preserve vegetables through fermentation. Learn about the illustrious history of fermented vegetables, the science behind it, and how simple it is to ferment vegetables yourself at home. This talk is hosted by [Sandor Ellix Katz](#), a fermentation revivalist. His books [Wild Fermentation](#) and [The Art of Fermentation](#), along with the hundreds of fermentation workshops he has taught around the world, have helped to catalyze a broad revival of the fermentation arts. A self-taught experimentalist who lives in rural Tennessee, the New York Times calls him “one of the unlikely rock stars of the American food scene.” Sandor is the recipient of a James Beard award and other honors.

Watch the talk

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Vegetable Fermentation | Fermentology mini-seminars

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Introduction

It's a pleasure to be part of this Fermentology series — and our theme today is vegetable fermentation.

A sourdough or any fermentation of grains or of beans have nothing to do with preservation. They have to do with digestibility. They have to do with lightness of the bread. They have to do with nutrient bioavailability. But nobody ever ferments grains in order to preserve them because they're so stable in their mature form when they dry on the plant. And then you can just keep them in a jar or a bag until you're ready to use them. And then the first step of the fermentation is always introducing water, which awakens the dormant organisms that are on them.

With vegetables, it's a very different story because vegetables, to varying degrees, are perishable. And generally, the primary motivation for fermenting them is preserving them. And so in general, you see more traditions of fermenting vegetables in colder places with short growing seasons and long winters without fresh vegetables than in tropical places where vegetables are available all year around. But that doesn't completely hold true.

The Organisms in & on Vegetables

So in terms of the fermentation, the fermentation of vegetables is driven by lactic acid bacteria. One of the things that microbiologists and botanists have learned is that all plants have lactic acid bacteria. All plants growing out of soil on planet Earth have lactic acid bacteria. It doesn't necessarily hold true for, let's say, hydroponic vegetables. But anything growing out of soil has lactic acid bacteria.

So the bacteria that we need to ferment vegetables is always on the vegetables. But it's not the only organism on the vegetable. So the big questions with fermenting vegetables, as with fermenting most things, are: *Which of the multitude of organisms that are present on the food that we are fermenting, the substrate for the fermentation? Which of those organisms are going to grow?*

And so really the practice of fermentation has a lot to do with manipulating environmental conditions to encourage the growth of certain organisms while simultaneously discouraging the growth of other organisms.

So for instance, if we shred cabbage, which is the first step of making sauerkraut, put some salt on it, and then we leave that cabbage loosely shredded in the bowl — it's never going to turn itself into sauerkraut. And it's very predictable what will happen, which is that molds will develop on the surfaces.

I just so happen to have a piece of cabbage that has been sitting in the drawer in my refrigerator for three weeks or something — and the darkening of the surfaces indicates mold. And if you had a whole bowl of loosely shredded vegetables where all the surfaces had good air circulation and therefore access to oxygen, you would see these kinds of dark, fuzzy molds developing on all of the cabbage.

The environmental manipulation for fermenting vegetables in general is to get the vegetables submerged. And what this does is it protects them from the flow of oxygen and makes it impossible for mold to grow, except on the surface, which is the most vulnerable place.

But within the volume of it, molds can't grow. And what will dominate instead, every single time, are lactic acid bacteria. Now, to say that vegetables are fermented by lactic acid bacteria is a little bit of an oversimplification because what's really happening is that there is a succession of different strains of lactic bacteria coming into dominance in that environment as the fermentation proceeds.

So the community of organisms on the vegetables, the composition of that community, is evolving over the course of the fermentation. And it's being very much influenced by the changing environmental conditions, specifically the pH.

So as the environment becomes more acidic due to the early stage lactic acid bacteria producing lactic acid, it gives rise to other strains coming into dominance. And so generally, the organism that initiates it, which is a lactic acid bacteria that is believed to be universally present on plants growing out of a soil on planet Earth.

Leuconostoc mesenteroides is typically what initiates the fermentation and begins to generate some lactic acid. But as the environment becomes more acidic, it gives rise to more specialized populations.

In a fully acidic fermented vegetables that have had several weeks of fermentation and reaching a pH of below 4.6, typically what's dominating is *Lactobacillus plantarum*. So you have a succession of different organisms developing as the ferment matures.

Fermented Vegetables & Safety

This acid is what makes this so safe. Fermented vegetables, statistically speaking, are much safer than raw vegetables. We hear every year of outbreaks of food poisoning related to raw vegetables.

Usually, the story is manure from a factory farm uphill washed over some vegetables and ended up making some people sick. But even if you took vegetables like that and fermented them, as the lactic acid bacteria generate lactic acid, they would destroy the potentially pathogenic bacteria.

So like any kind of acidified foods, the fermentation of vegetables is a strategy for safety, which enhances the safety of these foods. And in fact, fermented vegetables are among the safest foods that are known.

Canning

Let me talk a little bit about preservation. Because in our time a lot of people can their sauerkraut. They use heat processing to make their sauerkraut even more stable so that they can eat it for years. Canning is a relatively new process.

Canning was invented a little bit more than 200 years ago in France. They call it appertization because they remember the name of Nicholas Appert — the French man who invented the process of stabilizing food using heat.

Sandor's Fermented Goods

But the fermentation of vegetables took some period of time. For example, I have a radish kraut, made from daikon radishes and some cabbages that I made in November. And it was really sitting in a vessel in my unheated cellar that more or less stays the Earth's temperature in the wintertime. And it was there, let's say, from November until the end of May. And then it's been in my refrigerator since then. The reason why it's been in the refrigerator since then is that once we get to summer temperatures and temperatures in the 90s during the day, my root cellar warms up.

It's not that this would become dangerous or toxic. It's that the texture would change. And it would go from being something crispy, which it is now, to something soft and mushy like baby food.

And basically what that is enzymes. What makes the vegetables crispy are pectins. And there are enzymes, pectinase enzymes, that digest the pectin. And once it gets warm or if you don't use adequate salt, then those enzymes will end up making it soft and mushy.

So by the time temperatures are really warming up I like to move this into the refrigerator for longer preservation. But it's really only through that cool part of the year that there are no fresh vegetables. That's what the practical survival aspect of this preservation always has been — to get people through the cool temperatures.

And I ferment all year around. For example, I recently prepped a little sour Mexican gherkins that are fermenting. But I'll just ferment these for like a week, and then I'll eat them or put them in the refrigerator.

In the summertime, this is a technique to flavor things and extend their life for a little while. But you really need cooler temperatures to do long term preservation. And the things that I'll ferment for long term preservation, I'll be making them in October and November. Whereas the things that I'm making now in the summertime are a shorter term endeavor just because I live in a place where it's very hot.

The History of Preserving Vegetables

Let's get into some history of this. This is an ancient practice, but no one can say exactly how ancient.

All of historical literature suggests that the idea comes from China. And that nomadic people of Central Asia encountered the idea of preserving vegetables through fermentation and spread the idea westward. This story is repeated throughout the literature. I can't really speak to what the origin of this story is.

The Techniques & Methods

Dry Salting

There's a lot of different techniques, but the easiest technique is the dry salting technique. All you do is you shred your vegetables to create surface area and then salt them. And the salt starts to pull juice out of the vegetables. The objective is to get the vegetables submerged under the juice to protect them from the flow of air and oxygen and molds growing.

So you shred vegetables and salt them. You can salt them very lightly. There's no minimum amount of salt that you need. It's possible to do with no salt, but it doesn't taste very good and it won't maintain a very good texture. So salt it.

The USDA number is 2.25% salt. That's really, for me, too salty. For most of the small-scale commercial producers that I meet, that's too salty. Most of the small-scale commercial businesses that I'm meeting are using somewhere around 1.5% salt.

Honestly, I typically don't measure the salt when I'm dry salting. I lightly salt as I'm shredding the vegetables. I mix it all together, I get in there with my hands and squeeze for a few minutes until everything's nice and juicy. The squeezing breaks down cell walls and helps release juices. And then once everything is juicy and mixed up, I'll taste a little piece. And I'll just evaluate the saltiness of it myself.

For example, a few weeks ago I made sauerkraut with cabbage and a little bit of carrot and some caraway seeds. In a quart sized mason jar with a wide mouth, I have this little glass disk, which is functioning as a weight — keeping the vegetables down, forcing liquid up, so that the vegetables remain fully submerged.

This is a newer one, a shorter term project. But the radish kraut that I mentioned previously that has fermented for so many months — this has a really, really intensely sour flavor. I love it. Some of you would love it. But probably some people would taste this and just wince at it, and just feel like that was too sharp of a flavor to be able to enjoy.

Another variant of the dry salting is you can make things like relishes and sauces. For instance, a hot sauce. I made a sauce like habaneros, which I put in a food processor with garlic. And then meanwhile, I cooked some sweet potatoes, cooled them down, and then I put the cooked soft flesh of the sweet potatoes mixed with the habaneros and the garlic and some salt. This I made last year. And I've been using this as hot sauce condiment.

With dry salting, where you're not adding any liquid, you get the most intense flavor of the vegetables. But the limitation of dry salting is generally you can't do a whole vegetable through dry salting.

Pickling

The whole vegetable that got me, as a kid, excited about pickles is a cucumber pickle with no vinegar. It's in a brine with garlic, dill, and grape leaves. In my upbringing in New York, we call this sour pickles.

One of the challenges of fermenting cucumbers is that they're ripe in the hot weather and they have a higher concentration of these pectinase enzymes. And so it's easy for them to become soft and mushy. But of course, that's when they're ripe is in the hot weather.

I always make sour pickles. I love them. But I just ferment them for less than a week at ambient temperatures on the counter — then I moved them to the refrigerator. In doing so, they maintain crunchiness really nicely. Another batch that I made are with the Mexican Spanish gherkins in a brine, in a saltwater solution.

Usually I mix the salt water solution at around 5% salt. That's saltier than I want my pickles to be. But an important concept is that you want as little brine as possible to cover the vegetables. The more water you add, the more you're diluting the flavor of the vegetables.

So you want to use less than half of your volume as brine. What that means is if you use a 5% brine, you're ending up somewhere around 2% in your salinity. It's harder to just do it by taste because it takes time for the

salt to absorb into the big vegetables.

But you can always adjust it. If after a couple of days it tastes too salty, you can add a little bit of water. If it tastes not salty enough, you can add a little bit of salt. So you can still adjust it.

Kimchi

Then there are hybrid methods — like kimchi. Typically for kimchi what you do is you brine the vegetables for some hours, or in some cases, some days. Then you drain off that brine, and then you make a spice mixture, which sometimes involves some rice. Sometimes it can involve fish sauce. There's a lot of variation in what it could involve.

I have made a cucumber kimchi — called a stuffed cucumber kimchi because I've made these little slits lengthwise in the cucumber and then when I was making it, I rubbed the spice mix into those.

There's lots of variations of kimchi. They don't all have chili pepper. Another kimchi that's all green uses ingredients like mustard greens and bok choy.

Oils & Sun

And then there's other methods. A lot of the Indian pickles call for the use of oils and sun. For example: a spicy lime pickle. With this, I sort of quartered each of the limes, but left them connected at the end, and then put salt and spices into them, stuffed them in the jar. And then for a couple of weeks I put them outside in the sun on sunny days. And that helps to pull juice out of the vegetables. And then also I put a little bit of mustard oil into the mix.

Japanese Pickling

With Japanese cuisine in particular, they have a lot of really interesting alternative pickling mediums. An example is kasuzuke. Here the pickling medium is kasu, which is the residue of sake making mixed with some sugar and salt. And then the vegetables are packed in there and fermented for a few months.

Japanese cuisine also has nuka pickles made from rice bran and koji pickles, where koji is the medium, miso pickles, soy sauce pickles, and of course vinegar pickles. There are lots of different kinds.

What is a Pickle?

Let me just clarify the word pickle because it confuses people sometimes because most of what we see on supermarket shelves are vinegar pickles. And that is a pickle. A pickle is anything preserved in an acidic medium.

One way to achieve that is to pour a hot vinegar mix over some vegetables. Another way is to allow the acidity to come from the fermentation by lactic acid bacteria. And it's just a completely different flavor. Lactic acid

versus acetic acid — they're both pickles.

Acetic acid vinegar is made from alcohol, which is made from sugar. So historically, vinegar has been kind of precious. It's really only in the mid-20th century when the process was developed for the distilled white vinegar that's cheaper than water at the supermarket, that vinegar pickling became really, really widespread.

It has the advantage of making something that is more shelf stable that can sit potentially for years. Fermented pickles are much more dynamic. But also they have what I would consider to be a much more interesting flavor as well as the benefit of probiotics.

Brine

I want to talk a little bit about brine. Because after you ferment you can end up with lots of extra brine. Here are some things you can do with your extra brine:

1. First of all, it's delicious. Drink it. Use it. Don't pour it down the drain. It's full of flavor. It's also teeming with lactic bacteria.
2. In some parts of the world, people use it medicinally. In Eastern Europe pickled brine and sauerkraut juice are renowned as hangover cures. But they're delicious. I use them in salad dressings. I use them as braising liquids.
3. Sometimes I end up with so much of it that I'll cook it down. So this is a seasoning in my kitchen that I call "eau de kraut." And this is basically a kraut juice cooked down about 10 times. So I started with let's say 10 gallons of brine and cooked it down to less than a gallon of brine. And so all that flavor is concentrated. So this is very salty and very acidic, but it's lovely as a seasoning for food.
4. Sometimes I will reduce it even further in a dehydrator to produce little crystals. Thus, this is kraut brine crystallized into salts. It's salty, but it also has all those other byproducts. It's also very acidic. And it just it has a lot, a lot going on. It's a really interesting seasoning.
5. One other use for extra brine is to make mustard. Rather than vinegar, or sometimes in addition to vinegar, you soak your mustard seeds in kraut juice and then blend it down. And if you want to make it a little bit more acidic for longer keeping, then you can add a little bit of vinegar to that.

Conclusion (& one more note on mold)

That's a little run down on vegetable fermentation.

Sometimes people get a little funky growth on the surface. And because we've all been raised to be so fearful of microorganisms (and associated food poisoning with that) a lot of people have thrown away their kraut, or kimchi, or other vegetable fermentation experiments, because it grew a little funky surface growth.

Don't throw it away. Remove that surface growth as best you can. Throw it in the compost. What's underneath it is fine. This is typical and to be expected. Anybody who experiments in this realm is going to deal with

surface growth. Sometimes it's a yeast called a kahm yeast. Sometimes it's a hairy white mold.

Remove it as best you can, discard it, and don't worry about it. In my travels in parts of the world where this has just been an important ongoing tradition that people are familiar with, they are so casual about that.

I was in China filming a video and this chef of a giant restaurant just mixed the surface growth right into his pickles without a thought, without any self-consciousness that we were videotaping him. It didn't even occur to him that it would be an issue for anyone.

This is a really normal part of the process. If it really disturbs you too much, there are specialized vessels that you can get that are designed to exclude air with oxygen, but give some kind of venting for the carbon dioxide that's produced by the process inevitably.

That's the biggest and most common problem that people have.