Some Science of Pickling Articles

There's a pickle for everybody!

WHAT IS PICKLING?

Pickling is one of the oldest forms of food preservation, dating all the way back to 2400 BC, as a way to prevent spoilage before modern refrigeration. The process involves submerging fruits, vegetables, meat, or plant roots into either a salt brine or vinegar in order to control the fermentation process. Because it's such an effective method, it's still widely used today.

PICKLES: INTERNATIONAL CUISINE

No matter what country you visit, you'll always encounter pickles in some form. Pretty much every type of food can be pickled. In the UK, for example, you may be offered pickled onions or pickled eggs with your pint of beer. In Myanmar, tea leaves are pickled to make a beloved salad called lahpet. In Hungary, pickles are made using the yeast from a slice of bread.

Hungry? Here's How to Make Oven-Baked "Fried Pickles."

HOW DOES IT WORK?

Obviously, if pickling has persisted so long, it works—but how exactly? It's all about acidity. Pickling drops the pH level of our food below 4.5, which is low enough to kill off most bacteria. When using vinegar to ferment pickled foods, the vinegar works to replace the water in the food, thus bringing down the pH.

For salt brines, the scientific process is a bit different. The naturally present lactobacillus bacteria survives the salt brine and suppresses growth of other bacteria as it quickly starts processing into lactic acid and carbon dioxide. Not only does it produce a crunchy, sour pickle, but it also positively influences the number of vitamins and minerals!

Depending on the level of sourness desired, pickling can take anywhere from 1 week to over a month. Though we now have many methods of preserving food, the number one reason pickling has stuck around all this time is simply because we love the taste!

https://www.exploratorium.edu/cooking/pickles/pickling.html

What is Pickling?
Pickling is a global culinary art. If you were to go on an international food-tasting tour, you’d find pickled foods just about everywhere. You might sample kosher cucumber pickles in New York City, chutneys in India, kimchi in Korea, miso pickles in Japan, salted duck eggs in China, pickled herring in Scandinavia, corned beef in Ireland, salsas in Mexico, pickled pigs feet in the southern United States, and much, much more.

What makes a pickle a pickle? On a most general level, pickles are foods soaked in solutions that help prevent spoilage.

There are two basic categories of pickles. The first type includes pickles preserved in vinegar, a strong acid in which few bacteria can survive. Most of the bottled kosher cucumber pickles available in the supermarket are preserved in vinegar.

The other category includes pickles soaked in a salt brine to encourages fermentation—the growth of "good" bacteria that make a food less vulnerable to "bad" spoilage-causing bacteria. Common examples of fermented pickles include kimchi and many cucumber dill pickles.

Pickling is not only an international food-preservation technique, it’s also an ancient one. For thousands of years, our ancestors have explored ways to pickle foods, following an instinct to secure surplus food supplies for long winters, famine, and other times of need. Historians know, for instance, that over two thousand years ago, workers building the Great Wall of China ate sauerkraut, a kind of fermented cabbage.

But pickling foods does much more than simply preserve them. It can also change their taste and texture in a profusion of interesting—and yummy—ways. It’s no surprise that cultures across the globe enjoy such an assortment of pickled foods, as you would discover on your international food expedition. In fact, food experts say, the evolution of diverse pickled foods in different cultures has contributed to unique cultural food preferences, such as spicy sour tastes in Southeast Asia and acidic flavors in eastern Europe.
Pickle Science: How to Master the Preserving Power of Acids

CHRISTINA WARD

Everything you need to know about how to make lacto-fermented and vinegar-pickled cucumbers.

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[Photographs: Vicky Wasik]

Place a finger anywhere on the globe, and I guarantee you that the local cuisine features some kind of pickled something. I will also guarantee you that the pickle you eat in Nairobi will taste similar to the pickle in Berlin, which is also akin to the pickle in Hokkaido. But why?

The answer is acid.

Let’s establish some common vocabulary. This is harder than you may think because of how the word ‘pickle’ is used. First, it’s a verb. To pickle something is to submerge it in an acidic solution or a solution that will become acidic. We (meaning every single English speaker on Earth) also use ‘pickle’ as a noun to refer to things that have been in that acidic solution. Because what is placed in that solution is so infinitely variable, the noun form of pickle can lead to funny misunderstandings. In North America, we call a pickled cucumber, a pickle. In England, pickle is an acidified spread made of mixed vegetables. Confused? Let’s back up even further. Why in the heck have people been putting their food in acid and acid in their food for thousands of years?

Acid Battery

Food preservation works by erecting chemical and physical barriers to pathogen growth, kind of like when Batman (Adam West, thank you very much) threw chairs at the Penguin’s minions during chase scenes. Raising the acid level in food is the best chair we can throw at microbes. But not all acids are created equal—a wide range of acidity levels are possible, from very weakly acidic milk all the way to incredibly potent hydrochloric acid. For an acid to be useful to us, we need to identify the ones that are both palatable as food yet strong enough to kill microbes.

We use the pH scale to measure how acidic or basic a solution is, and that scale ranges from zero to 14, with seven being neutral (neither acidic nor basic). Confusingly, the lower the pH number, the more acidic it is, so a high-acid food will actually have a low pH. Most of the foods we eat fall within the pH 2 to pH 7 range. The good news is that microbes are more sensitive to acid than humans are; their preferred range is a pH of 4.5 to 10.* This is good news because it leaves us with the range of pH 2.1 to 4.5 in which our foods will be safe from microbial infestation yet still tasty to eat.
Some people will say that microbes won't really be able to survive until the pH hits 4.6. I say that's a little too close for comfort, so it's better to err on the side of caution and bring that measurement down to 4.5 so we can feel secure that our food is solidly in the safety zone.

We’ve just identified a giant hammer in our food preservation toolbox: Changing the acidity of a food to within a range that is hostile to microbes yet palatable to humans extends the useful lifespan of that food.

Let's Get pHysical

Back to our pH measurements. The accepted pH range of food is about pH 2 to 10. So an acid with a pH of 1.8 is too acidic, and will cause burning in your mouth and throat. Really! (The same is true of highly alkaline substances; lye burns, for instance, are nasty, nasty injuries.) How can you determine the pH of your food? Measuring pH can be done by the home cook with one simple tool. No, not those little strips of litmus paper—their color changes can be difficult to read correctly. A simple digital pH meter does the job nicely. They can be found at home brew stores or online. I like and recommend the Hanna Checker Plus; it's relatively inexpensive and reads to the hundredth decimal point.

Let's be clear: You don't need a pH meter to make pickles, but having one is extremely helpful for adventurous and experimental pickle makers, as it gives you the information you need to make sure your pickles are in the safe zone. The rest of us can rely on trusted recipes and a few key principles and ingredients to make pickles safely at home.

Either way, we should all get to know our culinary acids. Acetic (or ethanoic) acid is the key component of vinegar; its pH measurement is approximately 2.4 at the 5% concentration found in most vinegars. Citric acid is found in all citrus fruits, but the ones used most often for preservation—lemon and lime juice—have a pH measurement of about 2. Tartaric, malic, and oxalic acids are found in tea, apples, stone fruits, and grapes. Those foods have an approximate pH range of 3 to 5. Out of all of these, acetic acid is the most useful to us when acidifying foods.

Wait! I know what you're going to say next: What about lactic acid? Lactic acid is created by the lactobacillus bacteria during the fermentation process that's essential to making yogurt, kefir, sauerkraut, and more. Lactobacillus is an 'acidophile,' which means it prefers to live in a slightly acidic environment. That's great for humans because lactobacillus not only doesn't cause us harm, but can also be beneficial to our digestive system. So yes, lactic acid creates an acidic environment that extends the life of a food, and we'll talk about lacto-fermentation a bit further along. Promise. But for now, acetic acid.

Acetic Arts

Making the vinegar brine for vinegar pickles, and prepping the jars for packing.

So what is acetic acid? A cursory examination would immediately reveal that a solution of acetic acid is colorless and has that unmistakable and pungent distilled-vinegar scent and sour taste. Producing it is a two-step process. First, a carbohydrate-rich organic material, like grapes, is fermented to make an alcoholic product, like wine. It’s then fed extra oxygen to create an environment that is perfect for the acetobacter bacteria to move in and consume the alcohol and produce acetic acid as a byproduct. I often explain it to kids like this: the poop of yeast is alcohol, and then acetobacter eats that alcoholic poop and poops out acetic acid. Gross, but true.

If your goal is to make wine, you don't want acetobacter around, since it risks turning your wine to vinegar, and there's not much fun in toasting an anniversary with glasses of that. But if your goal is to make vinegar, then you'd deliberately
introduce acetobacter to your fermenting wine. The modern method is to oxygenate huge vats of acetobacter-inoculated young wine as it's fermenting to produce a final mixture that is between 15 to 20% acetic acid. That mixture is then diluted with water to reach a 5% acidity. So your jug of distilled white wine is 95% water and 5% acetic acid, with a pH measurement of approximately 2.4.

Vinegar can be made from any alcoholic beverage. Wine vinegar is made from wine (fermented grapes), while cider vinegar comes from hard cider (fermented apple juice). White distilled vinegar comes from a grain or potato mash and balsamic vinegar is made from aged, fermented grape must (the leftover solids from the winemaking process). Most vinegars have a 5% acidity, but some specialty and flavored vinegars are mixed with a higher proportion of water for an acidity of 4%. This can be problematic for food preservation because our goal is to raise the overall acidity of our food, and a lower-strength vinegar may not give us the oomph we need. In any pickling recipe worth its salt (or should that be vinegar?), it will specifically tell you to use vinegar that has a 5% acidity. You may have never noticed it before, but every bottle or jug of vinegar will have its acidity percentage printed on the label in small print.

**Lactic Tactics**

Lacto-fermented pickles sit in a saltwater brine that gradually grows acidic with the help of friendly bacteria.

Lactic acid is a kissing cousin to acetic acid with just a slight variation in its chemical structure. It rates as less acidic on the pH scale, coming in at approximately 3.2 as measured in a finished fermented pickling brine. Lactic acid is also a product of fermentation, but the process for making it is just one step. To use my kid-science: Lactobacillus eats carbohydrates and poops out lactic acid. (When we're talking about acetobacter and lactobacillus, we're referring to the **genus** of those bacteria, but it's good to remember that there are subspecies that produce slight variations in the taste of both vinegar and lacto-fermented foods. When you hear the word 'acidophilus,' what that means is that the fermentation is due specifically to the *lactobacillus acidophilus* bacteria.)

According to the Mayo Clinic, active lactobacillus bacteria can be beneficial to your health. If you freeze or heat-process lacto-fermented pickles, you'll kill a lot of the microbes, including just about all of the lactobacillus. The pickles will remain safe and delicious to eat, because their high acidity ensures that, but they'll lose whatever health benefits the live lactobacillus may have provided.

**Pickling Time!**

Let's move along to what is happening when we pickle foods, both with the acetic acid in vinegar or with lactic acid in a lacto-fermented pickle. Let's use cucumbers as our example. When we soak cucumbers in a vinegar solution, the water in the cucumbers is gradually drawn out through osmosis into the pickling solution, which then becomes diluted. Meanwhile, the acid in the pickling solution slowly penetrates into the cucumbers. The acidity of the pickling solution is reduced overall, but the acidity of the cucumbers is elevated, rendering them safe from microbial infestation. The 'bad guys' are once again thwarted.

In lacto-fermented pickles, we start by making a brine from water and salt; that brine starts with a neutral pH of about 7. The cucumbers are placed into the brine, then weighted down to keep oxygen out. Lactobacillus, which lives all over the place, will find this crock of cukes in salt water to be the best house on the block and move in immediately. It helps to
visualize the process as farming—you're the bacteria farmer creating the perfect environment within which your lactobacillus will grow. This is when the magic happens, with the lactobacillus eating carbohydrates (sugars) in the cucumbers and pooping out lactic acid. With every passing day, the solution becomes increasingly acidic, which means it becomes increasingly hostile to unwanted pathogens. Eventually it reaches a safe acidity, at which point your cukes are as good as preserved.

It takes about three weeks in a jar for a whole cucumber to reach peak pickle using a vinegar solution and about four to six weeks in a fermenting crock with a salt-water brine.

Making Things Interesting

So far we know that we can preserve our cucumbers and give them a tart taste with either a vinegar or salt-water brine. But what about other ingredients that can improve the flavor and aroma of the pickles? **Spices** are one of the most common options.

Dill pickles are so popular in North America that the most commonly used blend of spices can be purchased under the generic name, "pickling spice," though even that varies depending on where you live. **This Dill Pickle recipe on Serious Eats** has just a few of the spices that we use in the Midwest, where I live. That doesn't make the recipe 'wrong,' it's just another iteration that bears the loving fingerprints of place and culture. In the Midwest, our pickling spices reflect German, Polish, and Serbian traditions. We're partial to cloves, allspice, mace, anise, juniper, and loads of mustard seed and turmeric. There are no incorrect choices when it comes to pickling spices, but whether you create your blend from scratch or use a premade mix, do take the time to get the freshest spices you can. I'm partial to my hometown purveyors, Penzeys.

**Herbs** like dill are another route to pickle flavor. I'm not sure if teenage boys still use 'dillweed' as a mild swear (they did when I was growing up), but *dill weed* is exactly what's needed for great pickles. It comes from the same plant as the young, feathery dill that's most common in grocery stores, but the "weed" is older and fully grown, often recognizable by its multiple flowering yellow heads. It's the flower that has the best flavor. During the summer pickling season, you'll sometimes see it in big bunches at farmer's markets and better produce markets. Often, it's labeled as "pickling" dill. Buy it. Use it. You won't regret it. (Of course, if you can't find dill weed, dried dill seed or the feathery baby dill will do in a pinch.)

Our last two ingredients, which are especially important for lacto-fermented pickles, are the **water** and **salt** themselves. The choices made here can be important to the success of your pickling. If you don't know much about your water quality, your best option is to use distilled water. Modern tap and well water are chock-a-block with additives (both wanted and unwanted) that can sometimes interfere with a successful lacto-fermentation. Where I live, our tap-water is off the charts with lead. Can you see where this is headed? If the goal is to ferment our cucumbers for a safely acidic result, then using water that might interfere with that could be a problem. That said, if you are lucky enough to have high-quality tap water, go ahead and use it.

It's best to use "pure" salt also. Canning salt, sea salt, pink salt, kosher salt—it doesn't matter as long as the label says it's pure salt. Table salt can be problematic as it's fortified with iodine and has additives to keep it from caking, both of which can cause clouding of the brine and discoloration of the pickles. This doesn't affect the ultimate safety of the pickles, but it makes them look unappetizing, which is not our goal.
Whether you want to add sugar in vinegar pickling situations is a question that's open for debate. The argument in favor of sugar is that it balances out the vinegar's sourness, creating a more pleasant, well-rounded flavor. I prefer them without any sugar, but I also loathe sweet bread and butter pickles. Of course millions of people love them, which is really just a way of saying that it's a matter of taste. And for anyone who read my article about the role of sugar and salt in reducing water activity for food preservation, rest assured, that's not their role here: The acidification of the food more than covers our food-safety bases.

Another optional ingredient is onions, though I'm confident that a fair amount of people will say that onions are never optional! (People either think onions must be in everything or should be obliterated from the planet.) The Eastern European-influenced picklers among you will want to add thinly sliced rounds of white onions, as I do in my recipes here.

Much has been written about the 'blue-green garlic phenomenon'; in fact, there's plenty written right here in this Food Lab article. A phenomenon specific to pickling, the teeny tiny residual amounts of copper in the vinegar or water can react with sulphur compounds in the garlic cloves and turn those buggers varying shades of blue and green. Don't lament if you find blue, green, or gray garlic cloves in your pickles! The pickles and garlic are safe to eat, though the garlic may taste bitter depending on the specific concentrations of sulphur compounds in the clove.

The last ingredient and star of the show is the cucumber. Not just any cukes will do—you need to find a variety that is suited to pickling. The ideal pickling cucumber is smaller than a slicing cuke with a pebbled exterior and less water inside. Look for Kirby, Excelsior, Wautoma, Jackson Gherkin, and other varietals for pickling. Talk to your local farmer or produce manager to find out if they're growing or getting pickling cucumbers. Farmers will ask you what size you want; the rule of thumb is more the rule of pointer finger: "Number One" pickles are the size of your pointer finger and command top price; midgets or cornichons are no bigger than a pinky-finger and are even more expensive; any cukes larger than your fingers are referred to as "Number Twos" and are, of course, cheaper. If you're looking to pickle whole cucumbers, get Number Ones. If you want to do slices or spears, Number Twos will work just fine.

Step-By-Step: How to Make Pickled Cucumbers

Step 1: Buy Fresh and Trim

The first step is to buy good quality, super fresh cucumbers. The most common pickle question I get is how to avoid mushy pickles. There are a couple of things that can cause this, but most of the time the culprit is age. Cukes from the grocery store are usually old. If you can, go to the farmers market and order your cucumbers fresh from the fields, so that they're no more than 24 hours old. As soon as you get them in your mitts, start making pickles. No delays. No goofing around! Those cucumbers started their march to decay as soon as they were harvested.

There are products on the market as well as folk-remedies to ensure crisp pickles, but using fresh cucumbers beats them all. Grape leaves, calcium chloride, alum, heck I've heard of people putting aspirin in their crock (please don't do that). Science shows us that most of these additives either don't work or introduce other problems to the pickle. Fresh is best.
The one trick for reducing cucumber softening that does work is to remove the enzyme residue from the flower-end of the cucumber. This little spot is the remnant of the blossom and is rich with enzymes that, when the cucumber is separated from the plant, accelerate decay. Get rid of it. Either slice off 1/8 inch from the blossom-end or gently scrape off the blossom end with a spoon or your thumbnail. That should be the first thing done to the cukes when you get them home. (And it goes without saying that you brought your cukes straight home to your kitchen without detours, delays, or stops at the ice cream shop.)

Step 2: Soak in Salt Water

After you've removed the enzyme deposits from the flower-end of the cucumber, place them into a brine of cold water and salt, using about 1 cup (250 grams/8 3/4 ounces) of salt per 1 gallon of water. As they soak, the salt works to draw out a bit of the water inside the cucumber, which helps make them even more crisp.

Step 3: Make Your Brine

To make a vinegar pickling solution, mix together water, vinegar, and salt; the ideal ratio is 3 quarts of 5% vinegar per 1 gallon of water and 1 cup of salt. For easy removal later, I like to put my basic pickling spice mix into a cheesecloth sachet or stainless steel tea strainer and then add it to the vinegar brine as well. A little heat helps dissolve the salt into the brine and more quickly extracts the pickling spice flavor, but make sure you cover the pot as any evaporation will throw the solution off, potentially rendering it overly salty and vinegary. After letting the spices steep for 15 minutes, I remove them, though how long you let your spices steep is up to you. It's just a question of how strong you want the flavor to be.

For the lacto-fermented pickles, you want to make a simple salt-water brine that's approximately 3.5% salinity, which is 35 grams of salt per liter of water. The process isn't so sensitive that you have to be quite so exact; different salts can vary in mass by volume, and yet you can still get away with measuring your salt by volume without messing your lacto-fermented pickles up. I find that warming the water to around 100°F (38°C) helps dissolve the salt.

Let both brines cool to room temperature before adding them to the cucumbers.

Step 4: Prep and Pack the Jars

Drain the cucumbers from the cold-water brine.

If you're going the lacto-fermented route, get your crock and gently wash it with warm, soapy water. None of this silly anti-microbial soap though, because we want microbes. We're not preparing for surgery. Don't despair if you don't have grandma's pickling crock. If you have a crockpot, you have a crock—just pull the insert out from the heating element and use that. Otherwise, a food-safe bucket or glass canning jars work too.

Next, build layers in the fermentation vessel, beginning with the dill flowers (if you have them), dill, some garlic, onion slices if you like, a layer of cucumbers, then sprinkle with some pickling spice. Repeat.

For vinegar pickles, quart canning jars work well and should either be washed with hot soapy water and then rinsed, or run through a dishwasher cycle. No need to dry them.

Packing cucumbers into a canning jar is a bit of an art. A visit to a county fair will reveal expert-level jar packs with beautiful, uniformly sized cucumbers perfectly lined up in the jar. If you plan on entering the fair, then do that.
Otherwise, your goal should be twofold. The first is packing the cucumbers, whether whole or speared, as tightly as you possibly can without completely crushing them. The second is keeping the cucumbers below the shoulder-line of the jar. (The shoulder of the jar is that slight curve below the opening.) A test for a strong pack is to place the palm of your hand over the opening of the jar and tip it upside down. Yes, some of the spices will fall into your hand, but the cucumbers should not move. If they do, you need to adjust. Swap out a bigger or smaller cuke or give the bottom of the jar a gentle thunk on the counter to help them settle. The task of packing a jar is futzy but pays off in the end. Just like lacto-fermented pickles in the crock, these cucumbers need to stay submerged in the pickling solution. A loose pack results in the dreaded floaters. Those cucmes won't be pickled and will turn mushy.

**Step 5: Add Brine to Pickles**

Adding vinegar brine to pickles.

**For vinegar pickles**, this is as simple as pouring your prepared brine over the tightly-packed cucumbers until they're fully submerged. If you're heat-processing the pickles, wipe the rims, put on the lids and bands. If these are intended to be refrigerator pickles, put on the lids and then put the pickles into the fridge.

**For lacto-fermented pickles**, you need to do a little more to ensure the cucumbers remain submerged. Remember, lacto-fermentation is an anaerobic process, which means exposure to oxygen in the air is your enemy. Start by pouring salt-water brine over the cucumbers in the crock to fully cover them. Then place a weight on top of the cucumbers to keep them submerged, followed by some kind of lid or covering.

There are commercial weights you can purchase that fit the exact interior diameter of a crock. Some families have a 'special' plate that is the correct diameter for their crock, and they weigh the plate down with something heavy. My husband still has the "pickle brick" his grandmother used to keep her plate submerged. For the rest of us, there's an easier way that costs nearly nothing: the water bag method. Simply fill a sturdy zipper-lock bag with salt water and seal it, pushing out as much air as possible. (The water in the bag doesn't touch food, but the salt helps prevent that water from getting icky.) Place that bag into another freezer bag of the same size and seal that one too. Then put the water bag flat across the cucumbers in the crock. The water in the bag is enough to keep the cucumbers below the brine. Cover the crock with a flour sack towel to keep out insects out, and that's it.

**Step 6: Store and Wait**

If you want to heat-process your **vinegar pickles**, place the sealed jars into a pressure canner and process for 15 minutes. Otherwise they can go straight into the fridge. Whether processed or refrigerated, the cucumbers need to stay in their jars for about 3 weeks to transform into pickles. Processed pickles last 12 to 18 months on the pantry shelf while fridge pickles last about 2 months. (The shelf life of fridge pickles always depends on how cold the refrigerator is and where in the fridge you place them; the back of the refrigerator is much colder than the shelves on the door.)

One thing to consider about heat-processing your pickles is that the heat interferes with the holy grail of perfect pickles: the crispy crunch. Any time you process your pickles in a hot-water bath or steam canner, you're cooking them. And cooking will result in
softer pickles. If your perfect pickle is akin to the Claussen or Vlasic brands you find in the refrigerator case at the market, then your only option for storing is in the fridge. If you choose to store your pickles in the fridge, it's a refrigerator pickle.

**For the lacto-fermented pickles**, the lactobacillus works its magic best at around 60°F (16°C) to 70°F (21°C). Sure, it can get hotter than that during the summer, but that’s also why folks keep fermenting crocks in basements or closets—somewhere that is cool and temperature consistent. Slow and steady gets you to the perfect pickle.

Check them every three days during active fermentation to ensure that nothing unwanted is happening in the crock. How do you know if something is bad? Well, you can see it. The cucumbers will turn gray and be disgustingly mushy. Sometimes you'll see a white mold-like substance bubbling on the surface; it's not mold but yeast. This is often called the scum. Having a yeast growth can adversely affect the flavor and quality of a pickle. Uninvited yeasts and molds compete with the lactobacillus, which means that your fermentation may not be producing enough lactic acid, which of course means it's not safe from harmful microbes. Some folks will skim the scum and keep on fermenting, but why? Our goal is perfect pickles, not kinda, sorta good pickles. You can skim if you want, but not me. On the other hand, if you see blue, green, pink, or black mold, that's it; the party's over. Molds are generally bad news. Sure, some people even scrape that stuff off, but I don't like to take those risks with food that I give to my family and friends. Compost that batch and start over.

How long will it take? Unknown. Deciding when your pickles hit their peak is a subjective and personal measurement. After about 3 weeks of fermentation, your pickles will start to look and smell, well, pickle-y. If you’re a fan of half-sours, this is when to place them in the fridge to slow the fermentation. If your tastes run more to the full-sour end of the spectrum, keep on fermenting, my friend: you've got another couple weeks until you get there. This is also the point where you need to decide what you're going to do with all your pickles. Storing them in the fridge keeps the lactobacillus alive but slows the fermentation process. If you put them into jars and then process them, they'll last for a year in the pantry, but the lactobacillus is dead (and, as with the vinegar brine, the pickles will soften in the heat).

That's it. Pickles. Using these methods and recipes one could literally pickle shoes. As with any chemistry project, keep your ratios exact and your equipment clean, and you will have Batman-approved perfect pickles.
The art and science of pickling
Chloë King takes a look at Britain’s rich history of pickling before shedding light on the entire process from start to finish. Writer and illustrator Chloe King is founder of the food lovers’ book club Cook the Books.

In the beginning
We have been preserving things in vinegar for literally thousands of years, meaning this method of food preservation is unarguably one of our most favoured and effective. At times of scarcity, along comes the humble pickle to relieve us of boredom or, more impressively, vitamin deficiencies. At times of feast, what better way to perk up a Boxing Day banquet than with a large dollop of piccalilli and a pickled onion? ‘When dishes survive there is good reason,’ writes Diana Henry in her excellent book Salt Sugar Smoke. ‘They are lodged in a country’s culture; they’re not faddy.’ So it is with pickles, which, on reading up, you will find have not changed significantly since the beginning.

In her eponymous Book of Household Management, Mrs Beeton writes endearingly of Greek and Roman pickles that ‘consisted of flowers, herbs, roots and vegetables preserved in vinegar’. Their various ingredients, macerated in oil, brine and vinegar, ‘often impregnated drop by drop’.

Of course, we have plenty of variations, from quick pickles to not-in-the-least-quick pickles, water pickles to oil pickles, refrigerator pickles to fermented pickles. But no matter where you go in the world, the one golden rule of pickling has remained since antiquity; to preserve all you can of the best quality you can find while it is available.

The essential components

Unlike some other dishes in the original Mrs Beeton, the spectrum of pickling recipes it contains would not feel out of place in a twenty-first century cookbook. Fancy a pickled nasturtium bud on your chia seed and sprouted mung bean salad? I do.

It’s unsurprising really. Today, top chefs like René Redzepi are celebrated for using often overlooked seasonal ingredients at their point of prime and preparing them in ways that are executed with precision. As if to prove that all good things come back around, Beeton recommended that we gather fruits intended for preservation ‘in the morning, in dry weather, with the morning sun upon them’. This harvest will have the ‘fullest flavour’, and keep well for longest, she said. The biggest mistake that novices make when making preserves of any kind, is using fruit and vegetables that are either over- or under-ripe.

Aside from an enviable batch of fresh produce, the essential element in pickle is of course vinegar, for its antimicrobial acetic acid. The word vinegar comes from the French vin aigre, which translates as sour wine. This is important to note, because not all vinegar is born equal, and more worrisomely, not all ‘vinegar’ is vinegar, as you will find if you read the side of the ‘non-brewed condiment’ commonly found at the chippy.

Good pickling vinegar should be a minimum of five percent acidity, and of a reliable quality. Unless you’re an expert, this is not one to make at home. The acetic acid plays a crucial role in warding off the growth of harmful bacteria that flourish in neutral or alkaline conditions and the balance of this is crucial to making a successful pickle.
In Britain, our favourite pickles are strongly influenced by Indian achars, and the most used pickling vinegar for the last century has been full-flavoured dark malt vinegar, which holds up well to the addition of spices (although you might equally go for a good quality cider vinegar). For a more authentic Nordic pickle, white wine or white vinegar does well, while Asian pickles are often made with rice vinegar.

The third thing to remember, in the same vein, is that the salt you use must be pure rock or sea salt. Conventional table salts contain additives that may make your sparklingly clear pickling liquor look like river water.

The process

Before modern farming methods made it possible to obtain vegetables out of season, it was common to keep adding ingredients to pickles as and when they were ready to harvest. In today’s germ-phobic era, the idea of opening and closing the pickle jar in such a manner is the stuff of nightmares.

In her book *An Invitation to Indian Cooking*, Madhur Jaffrey explains with relish how her grandmother insisted her celebrated lime pickles should only be stirred with the bare hand of a servant named Ishri, else they would spoil. As if to prove her right, Jaffrey reports that no other cook in the neighbourhood was able to make lime pickle to the same recipe.

Indeed, second to choosing the best ingredients for your pickle is your choice of how to make it. This is where things become a little reliant on your own willingness to experiment, as there are many slight variations on the basic method of brining raw vegetables, followed by bottling them in seasoned vinegar.

The humble pickled onion, for instance, can be subject to numerous treatments to varying ends. One Mrs Beeton method recommends brining the onions for three days; cooking them in hot, not boiling, milk and water solution, leaving them overnight then covering in just-boiled seasoned vinegar before bottling and leaving for four to six weeks. Another of her pickled onion recipes recommends simply covering raw peeled onions and whole spices in cold vinegar and letting them stand for a fortnight.

On the whole, twenty-four-hour brining or dry salting is necessary for pickles you intend to keep for any length of time. This stage draws out moisture from the vegetables, prohibiting it from leeching out, colouring the vinegar and diluting its acidity. Leiths suggests a ratio of 225g salt to 2.8 litres of water as an adequate brine.

Next, the vinegar is heated with whole spices that infuse flavour well and do not cloud the liquid. Juniper, allspice berries, cloves, dried chilli, bay, fennel, peppercorns and mace are common, as is the use of fresh dill. Scandinavian pickles tend to be sweeter and more

Salt duck and pickled prunes by Jeremy Lee

Pickled mushrooms by Chloë King

Pickled cockles by Will Holland
dilute, with vinegar mixed 1:1 or 3:2 with water and sugar added. A stainless steel pan is necessary here, as copper, iron and brass pans can spoil in high-acidity.

Once cool, the vinegar is poured over the rinsed, prepared veg in clean jars. Rubber-sealed Kilner or parfait jars are best for pickling as they are sturdy and easily cleaned. To sterilise, rinse well in hot soapy water and heat through in a low oven for fifteen minutes. Be sure to replace the rubber seals with new after each bottling: a good fit is not guaranteed twice, and the material can deteriorate.

How to sterilise jars for jams and preserves

Pickled fennel by Chloë King

The twist

Pickling is as much about observation as it is invention. All cookery is about transformation, and of time, as it does with a pickle, it can be difficult to experimentation and openness to chance.

The conditions your pickles are stored in, whether cool or cold, and the length of time they are kept before eating will all have an impact on the end product. A just-made pickle is typically sharper to mature.

Look to individual recipes from reliable sources for tips about how best to pickle different types of vegetable according to their individual qualities. Explore international variations. Follow recipes closely when it comes to their salt, sugar and vinegar content, as this magical trio will ward off mould. You are then free to play in terms of the aromats you choose, at what point in their development you serve them and what with.

In the words of Diana Henry, ‘innovation and adventure are perfectly possible with pickles and chutneys. You don’t have to worry too much about science’.

Additional resources:

https://www.exploratorium.edu/cooking/pickles/pickling.html

https://www.finecooking.com/article/the-science-of-pickles


https://www.greatbritishchefs.com/features/the-science-of-pickling
How To Make Homemade Sauerkraut in a Mason Jar

**YIELD** Serves 8, Makes 1 to 1 1/2 quarts

**PREP TIME** 15 minutes

**INGREDIENTS**

1 medium head green cabbage (about 3 pounds)
1 1/2 tablespoons kosher salt
1 tablespoon caraway seeds (optional, for flavor)

**EQUIPMENT**

Cutting board
Chef’s knife
Mixing bowl
2-quart wide-mouth canning jar (or 2 quart mason jars)
Canning funnel (optional)
Smaller jelly jar that fits inside the larger mason jar
Clean stones, marbles, or other weights for weighing the jelly jar down
Cloth for covering the jar, such as cheesecloth
Rubber band or twine for securing the cloth

**INSTRUCTIONS**

**Clean everything.** When fermenting anything, it's best to give the good, beneficial bacteria every chance of succeeding by starting off with as clean an environment as possible. Make sure your mason jar and jelly jar are washed and rinsed of all soap residue. You'll be using your hands to massage the salt into the cabbage, so give those a good wash, too.

**Slice the cabbage.** Discard the wilted, limp outer leaves of the cabbage. Cut the cabbage into quarters and trim out the core. Slice each quarter down its length, making 8 wedges. Slice each wedge crosswise into very thin ribbons.

**Combine the cabbage and salt.** Transfer the cabbage to a big bowl and sprinkle the salt over top. Begin working the salt into the cabbage by massaging and squeezing the cabbage with your hands. At first it might not seem like enough salt, but gradually the cabbage will become watery
and limp — more like coleslaw than raw cabbage. This will take 5 to 10 minutes. If you'd like to flavor your sauerkraut with caraway seeds, mix them in now.

**Pack the cabbage into the jar.** Grab handfuls of the cabbage and pack them into the canning jar. If you have a canning funnel, this will make the job easier. Every so often, tamp down the cabbage in the jar with your fist. Pour any liquid released by the cabbage while you were massaging it into the jar. *Optional: Place one of the larger outer leaves of the cabbage over the surface of the sliced cabbage. This will help keep the cabbage submerged in its liquid.*

**Weigh the cabbage down.** Once all the cabbage is packed into the mason jar, slip the smaller jelly jar into the mouth of the jar and weigh it down with clean stones or marbles. This will help keep the cabbage weighed down, and eventually, submerged beneath its liquid.

**Cover the jar.** Cover the mouth of the mason jar with a cloth and secure it with a rubber band or twine. This allows air to flow in and out of the jar, but prevents dust or insects from getting into the jar.

**Press the cabbage every few hours.** Over the next 24 hours, press down on the cabbage every so often with the jelly jar. As the cabbage releases its liquid, it will become more limp and compact and the liquid will rise over the top of the cabbage.

**Add extra liquid, if needed.** If after 24 hours, the liquid has not risen above the cabbage, dissolve 1 teaspoon of salt in 1 cup of water and add enough to submerge the cabbage.

**Ferment the cabbage for 3 to 10 days.** As it's fermenting, keep the sauerkraut away from direct sunlight and at a cool room temperature — ideally 65°F to 75°F. Check it daily and press it down if the cabbage is floating above the liquid.

Because this is a small batch of sauerkraut, it will ferment more quickly than larger batches. Start tasting it after 3 days — when the sauerkraut tastes good to you, remove the weight, screw on the cap, and refrigerate. You can also allow the sauerkraut to continue fermenting for 10 days or even longer. There's no hard-and-fast rule for when the sauerkraut is "done" — go by how it tastes.

While it's fermenting, you may see bubbles coming through the cabbage, foam on the top, or white scum. These are all signs of a healthy, happy fermentation process. The scum can be skimmed off the top either during fermentation or before refrigerating. If you see any mold, skim it off immediately and make sure your cabbage is fully submerged; don't eat moldy parts close to the surface, but the rest of the sauerkraut is fine.

**Store sauerkraut for several months.** This sauerkraut is a fermented product so it will keep for at least two months and often longer if kept refrigerated. As long as it still tastes and smells good to eat, it will be. If you like, you can transfer the sauerkraut to a smaller container for longer storage.
RECIPE NOTES

**Sauerkraut with other cabbages:** Red cabbage, napa cabbage, and other cabbages all make great sauerkraut. Make individual batches or mix them up for a multi-colored sauerkraut!

**Canning sauerkraut:** You can process sauerkraut for longer storage outside of refrigeration, but the canning process will kill the good bacterias produced by the fermentation process. See this tutorial from the [National Center for Home Food Preservation](https://nchfp.ars.usda.gov) for canning instructions.

**Larger or smaller batches:** To make larger or smaller batches of sauerkraut, keep the same ratio of cabbage to salt and adjust the size of the container. Smaller batches will ferment more quickly and larger batches will take longer.

**Hot and cold temperatures:** Do everything you can to store sauerkraut at a cool room temperature. At high temperatures, the sauerkraut can sometimes become unappetizingly mushy or go bad. Low temperatures (above freezing) are fine, but fermentation will proceed more slowly.