Traditional fermenting crocks were made of pottery or clay. Cabbage would be packed tightly in, a cloth large enough to drape over the crock and cover the top of the cabbage was placed next. Weights were then used to weigh down the cloth-covered cabbage. The brine would then be at or over the level of the rocks, providing a brine seal. If any mold did get on the top of the brine, it wouldn't reach past the rocks and cloth, and the cabbage below was safe.

Often, an additional step was created, similar to the current Germanic designs of a "moat" around the lid where water would be filled, creating a barrier between the oxygen outside and the ferment inside. The small amount of oxygen left inside would be quickly pushed out with the help of carbon dioxide produced by the lactic acid bacteria. This method ensures air could be pushed out through the water, but none could make it in. Current German and Polish crocks like these were designed from these traditional crocks that were made and used hundreds and even thousands of years ago. They have been updated somewhat to provide for more consistent results.

Koreans would bury theirs in the ground, providing a barrier from the air. Other cultures used the stomachs of animals or other various organs that would allow for carbon dioxide to be released without allowing air inside.

They didn't have a fancy airlock or pH measures– but they knew to keep the oxygen out using a simple, yet effective method.

Today the use of glass with an airlock and a cover around it to prevent the loss of vitamin C through exposure to light are sufficient and effective.

Benefits of Ferments that Traditional Cultures Experienced

The art and science of fermenting foods has been around for thousands of years. Traditional cultures may not have known the science behind fermenting and they did not have refrigeration. It was simply a practical way to extend the viability of their food supply. Traditional cultures experienced the benefits of increased vitamins levels and the ease of digestion in a fermented food like sauerkraut.

Although they wouldn't have realized that naturally-occurring toxins were reduced and pathogens were destroyed. They saw the detoxifying effects of the acidity of sauerkraut by noticing that it did not spoil. What they had was a food full of lactic acid bacteria which has now been discovered to be probiotic.

3 Stages of Fermentation – Sauerkraut

What's going on in a ferment?

Fermentation in general has been defined as "a biochemical change which is brought about by the anaerobic or partially anaerobic oxidation of carbs by either micro-organisms or enzymes." This is distinct from putrefaction which is proteins being broken down.

In sauerkraut, the fermentation process has a very specific purpose: to quickly proliferate through the food by lactic acid-producing bacteria (LABs), primarily Lactobacilli. These Lactobacilli cause the pH to be reduced, making the environment acidic and unsuitable for the growth of unwanted bacteria. Since the goal of making sauerkraut is to provide the best environment for Lactobacilli to grow, it pays to get to know LABs and what makes them thrive.

What Are Lactic Acid-Producing Bacteria?

Lactic acid bacteria (LABs) produce lactic acid as the result of digesting carbs. LABs are vital for fermenting cabbage into sauerkraut (as well as making sourdough and dairy kefir).

Although LABs in general are anaerobes, which make it very hard for them to live in the presence of oxygen, there are different sub-groups of LABs. One of these are the LAB Producers, and these include the microaerophiles Lactobacilli and Leuconostoc, which are vital for sauerkraut fermentation. By definition microaerophiles require small amounts of oxygen to function. The sauerkraut in your jar is sufficient for this process.

The three stages of sauerkraut fermentation

In order for sauerkraut to be a success, it must go through three specific stages of fermentation.

Stage One lasts between one and three days

Leuconostoc mesenteroides initiates sauerkraut fermentation. Since Leuconostoc mesenteroides produce carbon dioxide, it effectively replaces the oxygen in the jar, making the environment anaerobic (oxygen-free). When lactic acids reach between .25 and .3%, Leuconostoc mesenteroides bacteria slow down and die off, although enzymes continue to function.

Stage Two lasts for 10-30 days

Lactobacillus plantarum and Lactobacillus cucumeris continue the ferment until lactic acid level of 1.5-2% is attained.

High salt and low temp inhibit these bacteria, so I hope you didn't over-salt your cabbage – and be sure not to refrigerate yet.

Stage Three This final stage lasts under a week.

Lactobacillus brevis (some sources also include Lactobacillus pentoaceticus) finish off the ferment. When lactic acid reaches 2-2.5%, they reach their max growth and the ferment is over.

You will know your sauerkraut is ready for long-term storage (or to eat!), when no more bubbles appear on the sides or top of your jar.

What can affect the way my sauerkraut turns out?

Although the process is simple, and will complete well on its own with the right amount of salt added, there are some factors that do influence how sauerkraut will turn out. These are: moisture, oxygen concentration, temperature, nutrients, and pH. Let's address these one at a time:

Moisture

Bacteria that love to spoil sauerkraut will have the upper hand if you have an insufficient level of brine. Too low a water/brine level and you're giving the undesirable aerobic (oxygen-loving) bacteria and yeasts the food they need to grow on the surface. This can cause off-flavors and discoloration at minimum, or even an allergic reaction to those with sensitivities to mold and yeast.

Although white yeast "scum" on the surface can be scraped off without harm to you, mold is another story and will be addressed further in another section. Briefly, one way to eliminate the mold problem (because you certainly can't drain the moisture out of your 'kraut) is to make sure oxygen exposure is kept to an absolute minimum since molds need oxygen to survive. Which brings me to…

3 Stages of Fermentation – Sauerkraut

Oxygen Concentration

Lactobacillus plantarum, the primary bacteria responsible for Stage Two, works best without oxygen. Anaerobically (without oxygen), Lactobacillus plantarum does their job the way we want them to – they cause fermentation of cabbage via lactic acid. Aerobically (with oxygen), it will produce acetic acid (vinegar). Since we're making sauerkraut, oxygen must be avoided.

Sauerkraut that is allowed oxygen will not contain any vitamin C in the final product after just six days. It will also increase chances of mold forming. If you are regularly getting mold on the top of your cabbage, this is a visible sign you are allowing too much oxygen in. Oxygen also allows pink yeasts to grow and could result in soft 'kraut.

Finally, don't mess with your brine. When brine is stirred, you introduce air which make conditions more favorable for growth of spoilage bacteria.

Temperature

Micro-organisms are classified into three categories according to their temperature preferences. Since sauerkraut falls into the mesophilic category, the bacteria involved prefer a minimum of 10-25° C; an optimum of 30-40° C, and a maximum of 35-44° C. These are the temps that all bacteria prefer (non-pathogenic as well as pathogenic).

In the first stage of fermentation as described above, the Leuconostoc mesenteroides from stage one likes a temperature range of 18-22° C. It's a little flexible, and built to resist some change in temp.

The second- and third-stage bacteria Lactobacillus plantarum, Lactobacillus cucumeris, Lactobacillus pentoaceticus, and Lactobacillus brevis prefer a temp of 22° C – 32° C.

It's important to keep these temps in mind, to be sure you provide the right environment for these bacteria to grow.

Temperature also affects enzymes, which are destroyed once the temperature has risen to 46 ° C.

3 Stages of Fermentation – Sauerkraut

Nutrients

Nutrients also affect the outcome of sauerkraut, salt being the primary nutrient of concern.

Salt should be added at a ratio of about 2-3%. Much more than this and the Lactobacilli can't thrive. A good rule of thumb is one tablespoon of salt per two pounds of cabbage.

Add salt as evenly as possible – if you create pockets of cabbage that aren't salted, you are sending an open invitation for spoilage bacteria to invade and turn your cabbage brown, or for yeasts to turn it pink.

Pure sea salt is essential. Salts with added alkali may neutralize the acid, resulting in a failed sauerkraut.

pH

pH is a measure of hydrogen ion concentration. Foods with a pH above 4.6 are low acid and these foods won't prevent bacterial spoilage.

However, since sauerkraut has a pH of 4.6 or lower, it is termed a high acid food. This acidic environment will not permit the growth of bacterial spores and thus is resistant to spoilage.

Lactobacilli thrive in an acid environment, but so can molds and yeasts. So it's important to find out what the mold and yeast don't like that Lactobacilli can tolerate in order to prevent mold and yeast from growing at all. I discuss this next.

Signs you're doing it right – or wrong

Understanding the particulars on moisture, oxygen, temperature, salt and pH is important. It's easy to tell if your brine is above your cabbage, and you can use a thermometer to check temperature. You've measured your salt correctly, and you can use pH strips or meter to test the acidity. That leaves us with oxygen. How do you know if you're keeping out enough?

There are visible signs to help you figure out if your set-up is working.

Firstly, you will see your cabbage darken. It will turn a brownish color. This also tells you your vitamin C content is tanking – or gone. If you have a pinkish color

going on (and it's not from adding red cabbage) then you have a yeast issue. Finally, you could have mold.

All three of these are preventable. All three, like lactic acid bacteria (LABs), can survive in an acidic environment. But how do you kill off the yeast and mold without harming the vitamin C, and while keeping the lactic acid bacteria happy?

Keep the oxygen out.

Yeast and mold both need an oxygen source to thrive. Vitamin C deteriorates when exposed to oxygen after just six days.

Mould

Is mould is a big deal or not. Sauerkraut is not cheese and should therefore be treated differently. In a microbial level it's a completely different world. Scraping off the mould, leaves its roots behind and ingesting this can end up causing digestive problems. I do not recommend at any time taking risks with mould. If you are uncertain – toss it!

Yeasts

Yeast is another major inhibitor which requires an abundance of oxygen for growth. It's often one of the first signs that you're allowing too much oxygen near your sauerkraut. In the presence of oxygen yeasts can be oxidized to form vinegar. We definitely do not want this in our sauerkraut. Yeasts can also cause off-flavors and discoloration, visible signs you need a better seal on your sauerkraut. Pink sauerkraut (not from red cabbage) is a sign of yeast. This could be due to too much salt, or an uneven distribution of salt, or too much oxygen exposure. If you see a creamy film on top and/or one that smells yeasty, throw it out immediately.

There is one yeast, however, that is helpful. Saccharomyces cerevisiae, a member of the ascomycetous yeast family (Fungi which produce microscopic spored inside special, elongated sacs, known as asci; as opposed to the candida family which has a large, globular shape) is probiotic and can help with candida overgrowth. Interestingly, Saccharomyces cerevisiae has the ability to shift its own metabolism from fermentative to oxidative. When present, oxygen will cause Saccharomyces cerevisiae to oxidize; keep the oxygen out,

and this friendly yeast can help your sauerkraut to ferment and provide you with delicious probiotics.

White Film, Slime, Sediment, and Starter Cultures

Although mold is harmful, white film is not. This is just your friendly probiotic yeast at work. This happens more often when cabbage isn't properly submerged under the brine, or the container isn't sealed well.

Slime, however isn't to be tolerated. This is most often the cause of too little salt, or salt that wasn't evenly mixed into the cabbage.

What about white sediment on the bottom of the jar? A small amount is normal and a good sign. When coupled with slimy sauerkraut, it's a bad sign.

Starter cultures –Although unnecessary, they aren't to be frowned on. Starter cultures can ensure consistency and speed up the fermentation process. Controlling a ferment in this manner can give consistent results. Using an inoculation from a previously successful batch will work as efficiently.