The Book of Fermentology

On the Culture of Cheese

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NC State University Libraries

Published on: Dec 03, 2021

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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. The transcript has been enriched with media, annotations, and links to other material by the digital publication team in order to amplify and extend the content for a reading experience.

Abstract

Dairying cultures around the world historically made their cheeses with the help of natural fermentation. We'll explore why their milk was so ideally suited to this microbiological transformation; and how cheesemakers cultivated the appropriate microbes from their milk for its preservation. We'll also talk about kefir, and how one can keep this traditional probiotic dairy culture at home.

Cover image: [Djath i njomë](#) by Violetamyftari ([CC BY-SA 3.0](#))

Watch the talk

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[On the Culture of Cheese | Fermentology mini-seminars](#) by [Applied Ecology](#)

Introduction

I'm a [cheesemaker](#), [cheese educator](#), cheese researcher and an [author](#) on all things cheesy. I travel the world— or used to travel the world, I should say— teaching traditional methodologies in cheesemaking and showing cheesemakers how they can work with the microorganisms in their raw milk. I show them how they can make cheese using more traditional natural methods that are contrary to the way most cheese is made today.

So I'm going to walk you through this lecture about the culture of cheese. I'm going to talk to you about the traditional ways that cheesemakers all around the world cultivate the microorganisms necessary for milk to evolve into cheese in its most appropriate and its best way.

But before I do, I want to talk about the circumstances in which cheese is typically made today and how that differs from traditional methods. Before I do that, though, I just want to show you some of my cheeses. I guess you might be interested in seeing what I do. I'm a farmstead cheesemaker, although these days I'm spending a bit more

time traveling on the road, teaching the subject. But I want to show you some of the things that I've made at home in recent months during quarantine. These are sorts of things you could be making at home using natural, traditional methods.

I have here a Camembert, made from pasteurized sheep's milk. It's growing a beautiful white rind on its surface, thanks to the help of a fungus called *Geotrichum candidum* that resides in raw milk. This is going to be ready in one more month or so.

Screenshot from [On the Culture of Cheese | Fermentology mini-seminars](#) by [Applied Ecology](#). David Asher holds a Camembert during his May 21, 2021 talk.

Screenshot from [On the Culture of Cheese | Fermentology mini-seminars](#) by [Applied Ecology](#). David Asher holds a Tomme, May 21, 2021.

I have a Tomme, a mountain cheese from France, here at home as well. It's growing a beautiful, natural rind that's been aging for a couple of months. This is a raw cow's milk cheese, made using traditional methods.

And a final cheese I want to show you is this little one here in a jar. It's called Saint Marcellin, and it has unique features on its rind. What you're seeing there is a sort of surface wrinkle. It's a biofilm, you might say, of beneficial microorganisms, a collection of bacteria, fungi, and yeast that grow on the surface. The dominant microorganism is a culture called *Geotrichum candidum*, which is a yeast and a fungus together in one. It's ripening this cheese. It's consuming the flesh of the cheese and making it liquid, slowly turning it into a goopy sort of soup within the little mason jar.¹

Screenshot from [On the Culture of Cheese | Fermentology mini-seminars](#) by [Applied Ecology](#). David Asher shows a close view of the top rind of a Saint Marcellin cheese made in a jar during his May 21, 2021 talk.

It is a rare sort of cheese. We don't see it much in North America, but in France, Spain, and Italy this kind of cheese is a little more popular. It's a style of cheese that's made typically with raw milk, with a community of microorganisms present in the raw milk that allows this cheese to develop the beautiful wrinkles without really any intervention. And the way this cheese—and the other cheeses mentioned here—is made is actually quite different from the standard methods of making cheese, at least here in North America

and to an increasing extent in Europe.

Modern Cheesemaking Techniques

Cheesemakers in our countries today typically use freeze-dried starter cultures. These are single strains of microorganisms raised in laboratories that cheesemakers add to their vat of (usually pasteurized) milk in order to bring about the sort of transformations that the cheesemakers are looking for in the particular type of cheese that they make.

So if they are making a Camembert, they'll introduce a starter culture of lactose, *Lactobacillus* microorganisms, that help them begin its fermentation. And then, a ripening culture that will help that cheese develop a beautiful white rind on its surface.

The microorganisms that grow on the rinds of the cheese develop naturally if you don't have these freeze-dried starter cultures. But this is the way cheesemakers do it. If they make a blue cheese, they'll introduce a freeze-dried starter culture of *Penicillium roqueforti*

[Tillamook cheese plant](#) by [Russell Lee](#) (public domain). A lactic ferment starter is added when the milk is poured into 10,000 pound stainless steel vats.

in order to help the cheese develop its blue veins.² If they're making a Chèvre, they'll buy a different package of starter culture. If they're making a hard Alpine cheese, they'll use yet another type of culture in order to make their cheese.

Altogether, if a cheesemaker wants 20 different styles of cheese, they've typically got to buy 20 different packages of starter culture and ripening cultures, each one to help cheese develop its particular character, flavor and appearance.

These cultures are not cultivated by the cheesemaker, of course. The cheesemaker can't cultivate them, they're for one-time use only. They're kind of like a bread yeast that typical industrial bread is made with today, where you have to buy the yeast from the manufacturer of the product. And you have to keep on buying it every time you want to bake a loaf of bread.

Compare that with sourdough, which is all the rage these days: the sourdough is a starter culture that can be kept by a baker and fed on a regular basis to provide all the microorganisms needed to bake the bread. And the bread starter, the sourdough, contains within it not just *Saccharomyces cerevisiae*³— the bread yeast that allows a commercial bread to rise— but rather a whole community of microorganisms that aids the complete fermentation of the bread, and makes it more flavorful. It gives it that sourdough tang if it's made a certain way. And perhaps makes it more nutritious because of the greater breakdown of the proteins and fats that happens with a more complete fermentation.

Traditional Cheesemaking Techniques

The way I practice my cheesemaking is more in line with this sourdough method of bread baking, where a cheesemaker keeps a culture at home rather than purchasing freeze-dried starters. And the culture that a cheesemaker keeps at home is actually very much like a sourdough. I advocate for cheesemakers to keep a culture called clabber, which is essentially a simple fermented milk, or a culture called kefir, which I will discuss in greater detail further on.

But I travel the world teaching these methods. And as I travel and engage cheesemakers all over the world, I learn more about other methods of traditional cheesemaking that have helped further my understanding of the way in which milk evolves into cheese in its most natural and original way. I want to share with you what I've come to understand about the way in which milk evolves into cheese in the traditional way, rather than the way cheeses typically made today.

Of course, this style of cheesemaking used to be very common before the days of freeze-dried starter culture that was invented about 100 years ago. All cheese was made in this way, made through the invocation of a fermentation that naturally progressed as a result of cheesemakers making cheese on a regular (often daily) basis, just like sourdough bread bakers bake on a daily basis in order to cultivate the starters necessary for their bread to rise. The cheesemakers historically cultivated the necessary microorganisms that enabled their cheeses to ferment without even realizing it, simply by making cheeses on a regular basis.

Traditional Fermentation Methods

There are essentially four ways in which traditional cheesemakers can keep the cultures that are necessary to invoke this traditional fermentation that allows their cheeses to evolve so deliciously and so safely.

1. In wood. By making cheeses in wood or other natural materials like this, the natural material itself carries culture forward from one batch of cheese to the next.
2. By saving whey from one batch of cheese to the next. Whey is a yellowish liquid that flows from the curd that has all the microorganisms of the milk and the cheese in it. Whey can be left overnight to ferment and then used as a starter culture the next day to invoke the fermentation.
3. By keeping a culture called clabber. I have a bit of clabber here. It's essentially a milk sourdough, and I call it a sour milk culture. Clabber can be kept and fed like a yogurt starter, and can be used to make cheese as well. We'll talk about this in a few minutes.
4. By keeping an ancient culture of microorganisms known as kefir grains.

Wood

Let's talk first about wood. The way wood and natural methods work in cheesemaking is that a wooden vat or cheese form holds on to the whey that comes out of the cheese as the cheese is made. If a cheese is made on a regular basis within the wooden vat, whey seeps into the wood and continues fermenting within the walls of the vat overnight. And the next day, when fresh milk is added to that vat still warm from the udder, the microorganisms that are held in the wood find their way into the milk. They mix into the milk and begin a cyclical fermentation that continues on within the walls of that vat.

There are very few cheesemakers these days making cheese in wood. This sort of material typically isn't allowed in commercial dairies, it's considered too much of a health hazard. But wood is the material that allowed most of our cheesemaking styles around the world to evolve. It's the nature of the wood that allows microorganisms to be carried forward from one batch of cheese to the next, and that has enabled all styles of cheese to exist.

[Cheese mould](#) by [Museum of English Rural Life](#) (CC BY-NC-SA)

I've had the good fortune of witnessing a traditional wooden vat in use by my friend, [Sister Noella](#), also known as the Cheese Nun, who makes cheese at her [abbey in Connecticut](#) using a wooden cheese making vat. She had to prove to health inspectors that the traditional methods that she used in a wooden cheesemaking vat actually help the cheese, and that she made it all safely. She went on to do a PhD studying the microbial ecology of the wooden vat to prove to her inspectors that this wooden vat was actually safer than making cheese with modern microbiological methods.

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[Sister Noella Marcellino: Tales from the Cheese Caves; Science & Cooking Public Lecture Series 2016](#) by [Harvard University](#) (© President and Fellows of Harvard College)

Whey

Wood works. And wood works by saving whey from one batch of cheese to the next. You might have seen whey seeping to the top of your yogurt. It carries in it a community of beneficial microorganisms that aided the fermentation of that dairy product. And if this whey is carried forward and saved for another batch of cheese, whey continues fermenting— with all the lactose and microorganisms present in it—

overnight until it becomes acidic. And the next day, that whey can be added to the milk to initiate a cheesemaking fermentation.

Though this is quite rare for cheesemakers to do here in North America today, there are cheesemakers in Europe who use whey as a cheesemaking starter culture. You may have tasted some of these cheeses before. Parmigiano Reggiano, for instance, is a cheese that's required by its [designation of origin](#) to be made with a whey starter saved from one batch of Parmigiano Reggiano to the next. And so it's understood that whey left to ferment will carry forward the beneficial microorganisms that allow milk to ferment.

Where did the first whey come from? This is a question I often pondered. You know, sure, you can save whey from one batch of cheese the next. But where do you get that first whey that allows that milk to initiate a fermentation? And the answer to that is that milk really develops its own fermentation, its own community of microorganisms that allow its transformation entirely on its own, simply by being left out to ferment.

Clabber

If you have access to raw milk, you can try this at home quite readily. You can take a glass of raw milk, preferably still warm from the udder with an intact microbial community. If you take that raw milk and leave it out at room temperature for two or three days that milk will naturally curdle, or clabber, into a sort of semi-soft yogurt with a mild and delicious tang.

We don't typically do that with our milk, especially our raw milk. We're told that milk has to be kept refrigerated in order to keep it safe, and to keep it from decaying. But that may just be the case with pasteurized milk. Raw milk has a community of beneficial microorganisms that are meant to be in it. And that may be meant to ferment it. By taking raw milk and leaving it out at room temperature, the microbial community that's a part of that milk begins to consume the lactose sugars in the milk, converting them into lactic acid. This develops a strong fermentation that can help protect that milk from unwanted decay.

Over the last two decades, scientists have become aware of the incredible community of beneficial microorganisms that's present in milk through studies of the microbiome of breast milk as well as cow's milk, sheep's milk and goat's milk. It turns out that milk is not sterile in the udder or breast, as we thought it was 20 or so years ago. Instead, milk carries forward an incredible community of beneficial microorganisms from mother to infant. There are biological pathways that exist in mammals that bring

beneficial microbes from the mother to the infant through the gut and through vaginal birth.

Milk is naturally meant to contain these microorganisms as part of the feeding of young mammals that drink their mother's milk. And when young mammals drink their mother's milk, they're not just getting nutrition from the milk, they're getting a community of beneficial microorganisms that aids that milk's fermentation, and which may be important to its digestion.

These microorganisms feed on the sugars in the milk and help establish a microbial ecology in the infant gut that helps establish the infant's immune system and helps with integral gut function. So it turns out that milk has a community of microorganisms that's meant to be in it, and these microorganisms are meant to ferment milk.

That means that when you make a clabber, when you allow milk to ferment and develop in that way, you're invoking a natural fermentation that may be meant to happen inside the gut of young mammals that drink their mother's milk.

This is the inevitable result of what happens when you leave raw milk to ferment: it curdles and thickens into a sort of yogurt. Quite delicious, although the first batch of yogurt may be a little odd or a little off because there aren't that many microorganisms in raw milk. On its own, raw milk doesn't actually ferment that well.

The first fermentation turns out a little odd, but once that milk ferments the first time, you can then take a little scoop of that culture out and put it into another jar and add in some fresh milk. And that fermentation will improve as a result of the addition of the starter culture. And by carrying the culture forward, or backslopping the culture forward from one batch to the next, you invoke a stronger fermentation.⁴ When you add that little bit of starter, there are many more microbes than there were in the raw milk and the fermentation initiates much more quickly. The starter can then be kept at home, much like a sourdough.

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[Backslopping Fermentation](#) by [Spoiled to Perfection](#)

You might even be able to start a sour milk culture with a sourdough culture. My experiences tell me that it's possible. When the culture is carried forward, if it's fed on

a regular basis it will provide endless beneficial microorganisms for your cheesemaking. And you can make all sorts of different styles of cheese like the ones that I showed you. The Camembert and the Saint-Marcellin are both made with a starter.

If you feed a starter on a regular basis, just like a sourdough, you may even see a beautiful white film, a fungus, growing on the top. And this is milk's *Geotrichum candidum*, the raw milk fungal culture that also establishes the beautiful white rinds on the cheeses that you make.

What if you don't have raw milk? If you don't have access to raw milk, don't fret. There are other ways to keep the culture of microorganisms that's necessary for our natural cheesemaking.

[Geotrichum candidum](#) by Supattra Intavimolsri, Department of Agriculture, Thailand ([CC BY 3.0 AU](#)). Scale bar = 10 μm .

Kefir

There's another culture out there, called kefir, which serves as a stand-in.

Kefir is an ancient culture, thousands of years old that you can hold in your hand.

Kefir is a fascinating culture, but it's also a very weird culture. It's one of the few communities of microorganisms that food fermenters keep that have a form like this. Sourdough doesn't have a form, it's just the liquid flour. The clabber culture is just sort of fermented milk. But kefir culture takes on this odd, cauliflower-like granule form.

So this is the culture that makes kefir, known as the kefir grain. It's not a grain like wheat or barley, but 'grain' meaning a small thing— as in a grain of sand or a grain of salt. This is a culture that's been kept for millennia by traditional fermenters and farmers over broad stretches of Asia. It's a culture that's only recently become popular in North America but has a long history in many other parts of the world.

It's a culture that makes a delicious dairy ferment called kefir. It's an extraordinary probiotic and maybe one of the best sources of beneficial microorganisms to aid our

gut's fermentation than any other food you can consume. And this culture also provides a fountain of beneficial microorganisms that can aid a traditional cheesemaker.

If you're working with pasteurized milk, adding kefir culture essentially un-pasteurizes that milk. It adds back to the milk many of the beneficial microorganisms that are taken away by the high-temperature cooking during pasteurization. So if you can't get access to raw milk you can still practice a natural traditional fermentation with pasteurized milk if you get a culture like this from a community of people who are keeping them.

[Simple pasteurization process](#) by Emma ([CC BY-SA 4.0](#))

As far as I understand, nobody's been able to recreate a kefir grain in modern times. They can't be synthesized in the laboratory. You can't just make them out of liquid kefir or clabber. They don't just come out of thin milk.

Origins of Kefir

Kefir grains that exist today are all descended from the original kefir grains that were discovered many millennia ago by semi-nomadic shepherds that most likely lived in Central Asia. And the kefir culture has been passed down from generation to generation by people who have valued it and recognized it as a spirit that enabled their milk to ferment into cheese. This fermentation process was essential for their well-being and survival.

The original people that discovered this kefir culture are believed to have lived somewhere in Central Asia between the Caucasus Mountains and Mongolia⁵. People in these regions still keep kefir culture today, and it may have been integral to their survival in the harsh Central Asian climate. These semi-nomadic shepherds kept goats and sheep, and in order to sustain themselves they milked the animals and transformed the milk into cheese. This allowed them get through the winter when they weren't milking animals.

[A khibitka dwelling of Kyrgyz with people, horse, camel and sheep](#) (public domain).

In order to make the cheese, they have to ferment their milk. And it's believed that the fermentation was naturally invoked by leaving fresh raw milk to ferment inside an animal skin bag hung from the rafters of a yurt, which is something that's still done today, essentially making a clabber. Once the milk fermented in that skin bag, as a

result of culture carried forward from one batch to the next, it could be drained in cloth, turned into cheese, salted, and preserved over the winter.

It's believed— although nobody's been able to repeat it in modern times— that kefir culture originated through that cyclical fermentation inside the skin bag. I've tried for years, to no avail. But you can try, too. Let me know if it happens, if you form them out of milk. I believe it's possible.

For me, what's special about kefir is that the culture can be held in your hand. You can feel it.

It's tangible, unlike many of these other cultures that are kept by fermenters. The culture has form. It's like a seed that you plant that invokes a fermentation that aids the preservation of milk.

I think our cheesemaking ancestors understood that. I think the discoverers of kefir grain recognized this to be something special and kept it, preserved it, and passed it on from generation to generation. The culture that I can hold today is believed to be the descendant of that original culture discovered by these semi-nomadic herders.

Not much evidence exists of this kefir culture in ancient times, except for one fascinating find that I want to share with you. There was a mummy found in desert regions of Western China, named the Beauty of Xiaohu. She was mummified and buried 3,400 years ago and preserved in the dry desert climate. She was buried with all sorts of interesting artifacts, including kefir grains on a necklace which she was buried.

Researchers at the [Max Planck Institute](#) in Germany [made this discovery](#) a few years ago by analyzing the proteins present in these little grains.^[1] They found that they were the same proteins that are created by certain microorganisms that exist in kefir culture. I believe that she was buried with the kefir culture because it was so essential to her in life that it would have been something necessary for her in the afterlife as well.

When you keep kefir and you tend to these kefir grains, you're tending to something with an incredible history to them. It's like an heirloom seed. It's like a traditional breed of animal that needs to be cared for in order for it to be preserved. And the culture itself can be gotten from other people that keep kefir, like myself. I give them to everybody who comes to my cheesemaking classes. You can also find them from folks online through community groups or folks that breed them at home and sell

them. I originally got mine from somebody who breeds them. I sent him \$20 in the mail and he sent me kefir grains in dried form.

That's what the Beauty of Xiaohe was buried with. Those were dried kefir grains around her neck. That kefir grains can be dried is part of the appeal, I believe, so that the culture could historically be kept through the winter. When the animals were dried down, the culture could be dried down as well. And in the spring, when cheesemaking had to recommence, the culture could be put back into milk and would come back to life again⁶.

The culture is pretty easy to source, because anybody that's keeping them also grows them. If you keep all the kefir grains they'll quickly take over your kitchen. So you have to find people to take care of them for you, to tend to your kefir babies.

If you take good care of the grains, you can pass the kefir grains onto your grandkids who can pass that culture onto theirs. This is the longevity of this culture. This culture will reproduce true, over and over and over again without contamination, so long as they're regularly cared for.

I believe them to be really a perfect cheesemaking starter culture as well as a wonderful probiotic. It has an incredible community of beneficial microorganisms that can aid the development of rinds of all sorts. So, these cheeses that I showed you, the Camembert, the Tomme, can all be made with the help of kefir culture. And the kefir gives *Geotrichum candidum* just like raw milk. They can help those cheeses develop their beautiful white rinds.

This is quite a large contrast with the freeze-dried starter cultures that cheesemakers use, which can't even be reused once. So there are lots of good reasons to keep these cultures, and lots of good reasons to ferment milk. This is a great way to preserve the most incredible food that's out there: milk.

On Cheesemaking

I believe that cheesemaking is a very involved craft, and one that is endlessly interesting to explore. I've been exploring it for 10 or 15 years now and I find myself continuously fascinated by the various transformations that milk takes. If you think sourdough is interesting, let me tell you, raw milk cheesemaking is mind-boggling.

I hope you have lots of fun fermenting milk. Be in touch. Let me know how it goes. If you want to follow along with what I do, you can find me at the [Black Sheep School of](#)

[Cheesemaking](#) and my cheesemaking book is [The Art of Natural Cheesemaking](#). I wish you all the best.

[The Art of Natural Cheesemaking](#) by
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Footnotes

1. [Recent research](#) on *Geotrichum candidum* proposes that “phenotypic and genomic results obtained in this study increase the scientific knowledge on the ripening yeast *G. candidum* and, in the near future, could be used to improve strain selection for cheese ripening processes.” [↵](#)
2. The *penicillium roqueforte* is a fungi notated first in Thom, C. 1906. Fungi in cheese ripening; Camembert and Roquefort. U.S.D.A. Bureau of Animal Industry Bulletin. 82:1-39. Read the [original report at the Internet Archive](#). [↵](#)
3. For more information on *Saccharomyces cerevisiae*, please see the related enriched talk [The Evolutionary History of Bread and Beer Yeast](#) [↵](#)
4. For a study of backslopping in kefir, see Kim et al., [Comparison of traditional and backslopping methods for kefir fermentation based on physicochemical and](#)

[microbiological characteristics.](#) ↵

5. [Central Asian Dairy Culture infographic](#), Insight Geostudio, 2021. ↵

6. [How-To Video: Reactivating Dried Milk Kefir Grains](#) ↵

Citations

1. Yang, Y., Shevchenko, A., Knaust, A., Abuduresule, I., Li, W., Hu, X., ...
Shevchenko, A. (2014). Proteomics evidence for kefir dairy in Early Bronze Age
China. *Journal of Archaeological Science*, 45, 178–186.
<https://doi.org/10.1016/j.jas.2014.02.005> ↵