

The Perfect Cacio e Pepe Recipe, According to Science

Italian scientists have drawn from thermodynamic principles to prevent a famous pasta from turning into a gooey mess.

▶ Listen to this article · 5:11 min [Learn more](#)

🎁 Share full article



The new research involved the consumption of roughly 11 pounds of pecorino cheese. Martina Gaiba

By Alexander Nazaryan

Published Jan. 24, 2025 Updated Jan. 28, 2025

[Leer en español](#)

A group of Italian physicists has dared to tinker with the traditional recipe for [cacio e pepe](#), the challenging Roman dish consisting of pasta, pecorino cheese and black pepper. In a new [study](#), the scientists claim to have “scientifically optimized” the recipe by adding an ingredient: cornstarch.

Cacio e pepe, which means cheese and pepper, is a showcase of Italian cuisine, with fresh ingredients producing bold flavor. The dish was supposedly invented by shepherds “who had to stuff their saddlebags with hypercaloric ingredients,” according to the new paper. Today, it is a staple at Rome’s classic pasta joints, where chefs steeped in tradition may not look kindly at scientific lessons on culinary thermodynamics.

The authors were aware they were treading on sensitive ground. “I hope that eight Italian authors is enough,” said Ivan Di Terlizzi, a statistical physicist at the Max Planck Institute for the Physics of Complex Systems in Dresden, Germany, who is originally from Puglia, Italy.

The recipe may be simple, but getting it right is anything but. The silky sauce comes together when pecorino cheese and ground peppercorns are mixed into the starch-heavy water drained from the cooked pasta. Doing so will ideally create an emulsion — a détente between substances that wouldn’t otherwise mix, as when oil and water form mayonnaise.

But as many cooks have discovered, the mixture of cheese and steaming pasta water can catastrophically result in what the researchers called the “mozzarella phase.”

Hot water causes whey proteins in the cheese to bend out of shape. They then bond with each other or with casein, the other protein in cheese, causing clumps.

The scientists wanted to find a surefire way to avoid that gummy mess.

“It’s very hard to get the right balance,” said Fabrizio Olmeda, a statistical physicist who worked on the new study and is from Rome, where [some say](#) the world’s best cacio e pepe is served at the [Felice](#) a Testaccio trattoria. “And sometimes when you get it correctly, you don’t understand what you did to make it good.”



The scientists heated variations of the sauce with a sous vide machine and built a wooden platform to hold the saucepan in place to ensure even heating. Martina Gaiba



The photography arrangement for identifying cheese clumps in the sauce, which stood out as dark blotches in the photographs taken with the tripod-mounted iPhone. Martina Gaiba

The scientists heated variations of the sauce with a [sous vide](#) machine, which maintains a consistent water temperature. They also built a wooden platform to hold the saucepan in place to ensure even heating. After heating, the sauce was poured into petri dishes that were then set on a cardboard box, the top of which had been replaced by a transparent film. A lightbulb illuminated the petri dish from below. The resulting arrangement made the cheese clumps stand out as dark blotches in the photographs taken with an iPhone mounted on a tripod.

“None of our samples were wasted,” said Giacomo Bartolucci, a biophysicist at the University of Barcelona and another author of the paper. “Our friends came by to say hi, to see how it was going. And they helped us, eating up all the samples.” Dr. Bartolucci estimated that the team’s research involved the consumption of 11 pounds of pecorino cheese.

The scientists tried the experiment at different temperatures and used different starch concentrations, and found that starch had much more of an influence on the consistency of the sauce. With enough starch, the entire process is “less sensitive to mistakes in temperature,” the paper said.

Starch is made of long strings of molecules, or polymers. As they absorb water and swell, the polymers bond with casein and prevent the whey proteins from clustering.

The traditional method of mixing the cheese in pasta water often comes up short because the water doesn’t hold enough starch. The scientists’ method does away with pasta water entirely; instead, store-bought cornstarch is dissolved in plain water and then heated before the addition of cheese. The researchers calculated that the ideal concentration of starch should be between 2 and 3 percent of the weight of the cheese. (Their optimized recipe, for “two hungry people,” calls for about $\frac{2}{3}$ cup of cheese and just shy of one teaspoon of starch.)

Italian gourmards may be skeptical, but experts in food science said the research was sound.

“What these guys did was a very impressive amount of work,” said Nathan Myhrvold, a former chief technology officer for Microsoft and culinary enthusiast whose cookbook “Modernist Cuisine” is widely considered a [bible of molecular gastronomy](#).

Even as he praised the Italian researchers for their starchy persistence, Dr. Myhrvold offered a different solution: adding sodium citrate, a widely available anticoagulant. He said that the large polymers of starch that prevent clumping can also blunt the flavor of the cheese.

In some ways, generations of Italian nonnas were scientists themselves, trying out recipes, observing the results and trying again.

“Cooking is chemistry. But most of all, it is experience,” said Lidia Bastianich, a [pioneer of Italian cuisine](#) in the United States. Just as the simplest scientific formula can be the most revolutionary, the simplest pasta bursts with the most intense flavors.

“Simplicity,” Ms. Bastianich said, “is the most difficult thing to reach.”