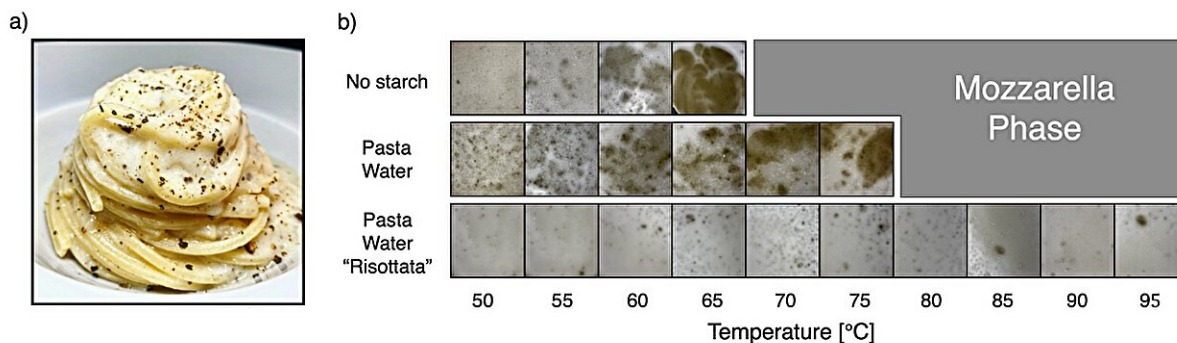


Physicists develop the 'perfect' recipe for a well-known Italian pasta dish

January 13 2025, by Bob Yirka



Cacio e pepe pasta sauce consists of pecorino cheese, pepper and starch-enriched water a) Tonnarelli noodles garnished with a mixture of pecorino cheese and starch-enriched water, and a sparkle of pepper. b) Snapshots of the mixture that constitutes the base for the pasta sauce, i.e., cheese and water with different amounts of starch, at different temperatures. Credit: *arXiv* (2025). DOI: 10.48550/arxiv.2501.00536

A small team of physicists at the Max Planck Institute for the Physics of Complex Systems, working with a colleague from Universitat de Barcelona and another from the Institute of Science and Technology Austria, has developed what they describe as a foolproof recipe for cacio e pepe.

In their [study](#) posted on the *arXiv* preprint server, the group took a

scientific approach to understanding the factors that can lead to the undesirable "mozzarella phase" when making the dish, and how they learned to avoid it.

Cacio e pepe is a well-known Italian [pasta](#) dish consisting of just three ingredients—pasta, pecorino cheese and [black pepper](#). Technically, there is a fourth ingredient: water. Also, the pasta is almost always spaghetti.

Making cacio e pepe is supposed to be easy—the cook simply boils the pasta in the normal way, extracts it, then adds grated cheese to the water that was used to cook the noodles, then adds pepper.

The problem is in getting the right combination of hot water (with the right amount of leftover [starch](#)) and cheese. If it is not done just right, curds develop (which the team describes as the "mozzarella phase"), which ruins the resulting product.

To come up with a recipe sure to please, the research team tried adding varying amounts of cheese to a constant amount of water and pasta at a constant temperature. As they did so, they took pictures of the final results, allowing them to create a sort of phase diagram showing the changes happening to the sauce as the conditions changed.

The would-be chefs found that there was a clear association between the temperature and the amount of protein from the [cheese](#) in the water; it was so clear they could chart it with a U-curve. At the bottom of the U, the curds form. They conclude this means that the amount of starch from the pasta is the key factor driving the development of curds. They also noted that starch levels in the water were generally lower than what was required for a good outcome.

Thus, cooks using pasta that left behind little starch were unlikely to produce the desired product. The solution, they found, was to add a little

cornstarch. This almost always prevented the development of the dreaded mozzarella phase.

More information: Giacomo Bartolucci et al, Phase behavior of Cacio and Pepe sauce, *arXiv* (2025). [DOI: 10.48550/arxiv.2501.00536](https://doi.org/10.48550/arxiv.2501.00536)

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