

Umami-rich scrap fish and invasive species can liven up vegetables, says gastrophysicist

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Fish roe (trout)



Dried/fermented fish (katsuobushi)

Dried fish roe (bottarga)



Seaweed (konbu)



Seaweed extract (dashi)



Seaweed (dulse)



Fish sauce/garum

Illustration of some of the marine food items described in the scientific paper as umami-rich blue food. Credit: Jonas Drotner Mouritsen

Greening the way we eat needn't mean going vegetarian. A healthy, more realistic solution is to adopt a flexitarian diet where seafoods add umami

to "boring" vegetables. University of Copenhagen gastrophysicist Ole G. Mouritsen puts mathematical equations to work in calculating the umami potential of everything from seaweed and shrimp paste to mussels and mackerel.

Most of us have a tough time eating enough veggies. According to the World Economic Forum only one in 10 people in the EU are getting the five portions of fruit and vegetables a day that are recommended both for the sake of health and climate. Which is natural, according to Ole G. Mouritsen, professor emeritus of gastrophysics and culinary food innovation at the University of Copenhagen's Department of Food Science.

According to Mouritsen, vegetables just don't taste all that good on their own. "Most people don't change the way they eat just for the sake of the climate. To really get things going, I think that every meal needs to be prepared to satisfy our [sense of taste](#). And, when many people have a hard time eating enough vegetables, it's because vegetables lack the sweetness and umami that we've been evolutionarily encoded to crave."

So, if we are to realize a green transition of our eating habits with diets that are far more plant-based, it might be a good idea to liven up vegetable dishes with more umami—the basic, brothy taste typically associated with meat. Here, Professor Mouritsen believes that the sea is a low-hanging fruit. Not only does the sea abound with protein, vitamins, minerals and [healthy fats](#), but also in much-coveted umami.

"We overlook the most readily available, and in many cases, most sustainable food sources with umami taste in them—namely fish, seaweed, shellfish, mollusks and other seafoods. If the right species are chosen, we can use them as climate- and environmentally-friendly protein sources that are also effective umami flavourants for vegetables," says Ole G. Mouritsen.

Using math to quantify umami

In a [research article](#) published in *International Journal of Gastronomy and Food Science*, Mouritsen uses a mathematical equation to help calculate the power of umami in a wide range of seafoods and demonstrate their great taste potential: $EUC = u + u \times \sum N \gamma(N)v(N)$. EUC stands for Equivalent Umami Concentration, which is the umami concentration in a food expressed in mg/100 g.

"Umami can be plugged into a formula because we know exactly how the taste receptors in our taste buds pick up on umami at the molecular level. There is a synergistic effect when two substances, glutamate and nucleotides, are present in a food at the same time.

Glutamate imparts the basic [umami taste](#), which is then enhanced many times over by nucleotides. This synergy is reflected in the equation," says Mouritsen, whose background is in theoretical physics.

The list of seafoods with large concentrations of umami is long. It includes everything from fish like cod and mackerel, to shellfish and mollusks like shrimp and octopus, to the roe of Alaska pollock and blue mussel, to various types of seaweed and on to processed seafood products like anchovy paste and fish sauce.

"There are many possibilities. And while some people will probably debate the formula's accuracy, it doesn't matter. Whether the umami concentration in shrimp, for example, is 9,000 or 13,000 mg/100 g is not critical, as each is much greater than 30 mg/100 g, which is the taste threshold for umami," Mouritsen points out.

Working wonders with the right sauces and dressings

Only a few drops or grams of blue foods are usually needed to elevate vegetable dishes to something that satisfies our inherited umami craving.

"Fish sauce and shrimp paste are obvious choices that some may already have in their kitchens or be familiar with from Asian cuisine. You can easily make sauces, dressings and marinades with them that elevate the taste above the threshold which brings out the umami in a vegetable dish," says Ole G. Mouritsen.

While it is easy for people preparing food in their kitchens at home to take part, it is first and foremost the professionals that Ole G. Mouritsen seeks to enlist.

"I've worked with chefs who have no problem preparing dishes where there is no compromise in taste, even when only a few grams of animal protein are present. It's a question of knowledge. And as scientists, we have a duty to share our knowledge," says the professor.

"Globally, many millions of meals are prepared daily outside the home—in canteens, hospitals, by meal delivery and recipe box services, in restaurants and in other contexts. It's the chefs, nutrition assistants and other culinary artisans who make the meals that, with the right knowledge, can move things forward."

We should be flexitarian

Professor Mouritsen believes that flexitarian diets are a more viable option than today's focus on replicating meat products using plants:

"I think we need to be more flexitarian. We need to get used to having a lot more vegetables and much less animal-derived fare on our plates. But in terms of taste, nothing should be absent. Therefore, my vision is that we add something from the [animal kingdom](#) that really boosts taste, so

that we can make do with very small amounts—but enough to provide flavors that vegetables can't," says Mouritsen.

"Here, it is obvious to use [raw materials](#) from the sea that can be sustainably made the most of. This includes species that are not overfished, species that are wasted as bycatch, or species that are not consumed by humans."

He emphasizes that it should be up to other professionals to determine which species are sustainable to use. While many fish species are overfished and a great deal of fish farming is environmentally harmful, the production of 'blue foods' sourced in marine and other aquatic environments is often far more sustainable than the production of land-based meat and plant protein, which often require large inputs of water and energy.

More information: Ole G. Mouritsen, When blue is green: Seafoods for umamification of a sustainable plant-forward diet, *International Journal of Gastronomy and Food Science* (2024). [DOI: 10.1016/j.ijgfs.2024.100902](#)

Provided by University of Copenhagen

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