Fishing out the bad apples: Novel quantitative method to assess the safety of food

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Spoiled food, especially fish, can have high levels of histamine, which can be dangerous to humans; thus, it is important to devise methods for the detection of such harmful chemicals in food Credit: Unsplash

Consumers of purchased foods have no way of ascertaining the quality and safety of the food that existing distribution systems deliver to their plates. Unfortunately, inappropriate refrigeration can sometimes lead to food spoilage, which is often difficult to detect. Such is the case for mackerel fish, which readily develop harmful levels of a substance called histamine when left at room temperature for too long. Histamine is neurotoxic and can trigger severe allergic reactions, including rashes, vomiting, and diarrhea. Because spoiled fish can sometimes look and smell completely normal, it is important to accurately quantify histamine levels in fish samples to ensure food quality has been properly maintained during transportation and storage.

Although several techniques to detect histamine exist, they generally require expensive and bulky equipment, as well as the presence of a qualified analyst. To address these limitations, a team of scientists at Chung-Ang University, Korea, recently developed a new quantification method that is simultaneously simple, effective, and inexpensive. In their study, which was led by Professor Tae Jung Park and Jong Pil Park and published in *Biosensors and Bioelectronics*, the team describes their novel approach based on the use of fluorescent carbon nanoparticles and a protein that binds strongly to histamine.

First, the scientists looked for peptides—short chains of amino acids—with the highest affinity and selectivity against histamine. To do this, they employed phage-display technology, in which the external proteins of genetically modified viruses are used to check for chemical interactions. After screening with a large peptide library, they identified the best one for their purposes, called "Hisp3."

Then, the scientists produced fluorescent carbon nanoparticles called 'carbon quantum dots (CQDs)' and coated them with N-Acetyl-L-Cysteine (NAC), a naturally occurring compound that also binds to Hisp3. The CQDs are fluorescent, meaning that upon irradiation with

ultraviolet light, they re-emit the captured energy at a lower, visible frequency. However, their fluorescence is 'quenched' when Hisp3 is added to the mix, which binds to the NAC and covers the CQDs' surface.

This last part is essential to the method because, when a histamine-containing sample is mixed with the CQDs, the Hisp3 unbinds from the NAC and binds to the histamine, restoring the original fluorescence levels of the CQDs in direct proportion to the concentration of histamine (as shown in the accompanying figure). By comparing the initial and final fluorescence levels of the CQDs using a fluorescence detection instrument or a handheld UV-irradiation flashlight, it is possible to indirectly quantify the concentration or intensity of histamine in the sample.

The proposed strategy was validated using fish samples with known histamine concentrations and other established techniques as well. Surprisingly, the new method proved to be more powerful than existing ones despite being simpler, as Prof. Park remarks, "We managed to accurately measure histamine concentrations ranging from 0.1 to 100 parts per million, with a limit of detection as low as 13 parts per billion. This means our approach is not only more convenient but also more effective and sensitive than those currently available methods."

Thus, this new method can not only detect dangerous histamine levels, but can also assess the state and quality of food products, as Prof. Park explains, "While the detection of histamine as a harmful factor is important, our approach can further serve to objectively measure the quality and freshness of food, thereby contributing to increasing food safety and benefitting consumers."

Additionally, the proposed methodology could be applied using other peptides to accurately determine the concentration of different

chemicals in food samples and biomedical specimens. If adopted by the food and medical diagnostic industries, this method could provide us with the much-needed assurance that the food we consume and the environmental conditions we live in are safe.

More information: Rongjia Shi et al, Fluorescence detection of histamine based on specific binding bioreceptors and carbon quantum dots, *Biosensors and Bioelectronics* (2020). DOI: 10.1016/j.bios.2020.112519

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