Turning up noses: E-nose detects real-time meat spoilage with 98.5% accuracy

11 Nov 2020 --- The freshness of meat, and therefore its safe consumption, can now be assessed in real-time with an artificial olfactory system that mimics the mammalian nose.

The technology could help reduce food waste by confirming whether meat is fit for consumption faster and more accurately than a best before date, suggests research from Nanyang Technological University, Singapore (NTU Singapore).

"Our technology provides a possibility for real-time surveillance of food safety, which is validated in the meat freshness monitoring scenario," Professor Chen Xiaodong, co-lead author on the research, tells ***FoodIngredientsFirst***.

Identifying spoiled meats

The e-nose consists of two parts: a barcode that changes color over time as decaying meat emits gases and a barcode reader in the form of a smartphone app powered by artificial intelligence (AI).

Professor Chen Xiaodong (left) led the international team that invented the e-nose *(Credit: NTU Singapore)*.

When tested on commercially packaged chicken, fish and beef meat samples, the team found that the AI algorithm predicted the meats' freshness level with a 98.5 percent accuracy.

The e-nose was 100 percent accurate in identifying spoiled meats and 96 to 99 percent accurate in "sniffing out" fresh and less fresh meats.

"The gold standard method in the food industry when it comes to meat freshness monitoring is the

Conway method, which is based on the total volatile basic nitrogen," says Chen.

"Despite its high accuracy, the Conway method is time-consuming, destructive, and takes several hours including grinding the meat, pretreatment of the meat and then titration."

Facing these bottlenecks, the team was inspired to develop "deep-barcoding technology," which relies on "scent fingerprints" that form on color-changing barcodes.

A deep convolutional neural network (DCNN) was co-developed to accurately recognize the scent fingerprint and classify the product as fresh, less fresh or spoiled.

"This method is quick (less than 30 seconds to obtain the results), non-destructive (based on gas emitted from meat), and real-time, making it fully compatible with food supply chains," explains Chen.

Product viability

In addition to co-authoring the study, Chen is president's chair professor in materials science and engineering at NTU Singapore, where the team, along with international collaborators, developed the e-nose.

He explains that the e-nose has a few distinct advantages over other spoilage-detecting contemporaries.

"Our proof-of-concept artificial olfactory system, which we tested in real-life scenarios, can be easily integrated into packaging materials and yields results in a short time without the bulky wiring used for electrical signal collection in some e-noses that were developed recently."

The barcode is also biodegradable and non-toxic, says Chen, meaning they could be safely applied in all parts of the food supply chain to ensure food freshness.

The e-nose uses a non-toxic, biodegradable barcode to detect changes in gases emitted by decaying meat *(Credit: NTU Singapore)*.

Imitating nature's nose

E-nose technology was developed based on a similar model to how the mammalian nose works.

When gases produced by decaying meat bind to receptors in the mammalian nose, signals are generated and transmitted to the brain.

The brain then collects these responses and organizes them into patterns, allowing the mammal to identify the odor present as meat ages and rots.

In the e-nose, the 20 bars in the barcode act as the receptors. Each bar is made of chitosan (a natural sugar) embedded on a cellulose derivative and loaded with a different type of dye.

These dyes react with the gases emitted by decaying meat and change color in response to the different types and concentrations of gases, resulting in a unique combination of colors that serves as the scent fingerprint.

For instance, the first bar in the barcode contains a yellow dye that is weakly acidic. When exposed to nitrogen-containing compounds produced by decaying meat (called bioamines), this yellow dye changes into blue as the dye reacts with these compounds.

The color intensity changes with an increasing concentration of bioamines as the meat decays further.

The e-nose has been trained to detect and draw meaning from these color variations, pulling from a large library of barcode colors.

Far-reaching applications

Chen further notes that this method for detecting food safety could benefit a number of different stakeholders.

"It could help food suppliers to classify food into different groups according to their level of freshness, and decrease food waste through sale strategies (i.e. selling less fresh but edible food first)," he suggests.

"The technology can also provide a transparent and self-service food monitoring system for customers, which could build their confidence in food safety in the industry," he adds.

A patent has been filed for this method of real-time monitoring of food freshness. The team is now working with a Singapore agri-business company to extend this concept to other types of perishables.

The e-nose is described in a paper recently published in the scientific journal *Advanced Materials*. In addition to the team of scientists at NTU Singapore, scientists from Jiangnan University, China, and Monash University, Australia collaborated on the project.

By Missy Green

To contact our editorial team please email us at editorial@cnsmedia.com