E-Noses – A Food Inspection Technology

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Abstract

E-noses, inspired by the human olfactory system, utilize arrays of chemical sensors to detect and analyse volatile compounds in food. These devices offer several advantages over traditional sensory evaluation and instrumental methods, such as speed, cost-effectiveness, and non-destructive analysis. The article discusses the history, principles, and components of E-noses, including gas sensor arrays, sampling systems, data acquisition systems, and data processing methods. Furthermore, it highlights the diverse applications of E-noses in the food industry, encompassing quality control, freshness assessment, authenticity evaluation, and origin tracing in various food products like meat, dairy, coffee, tea, and fruits. The conclusion emphasizes the potential of E-noses as a valuable tool for ensuring food safety, quality, and authenticity in the evolving food industry.

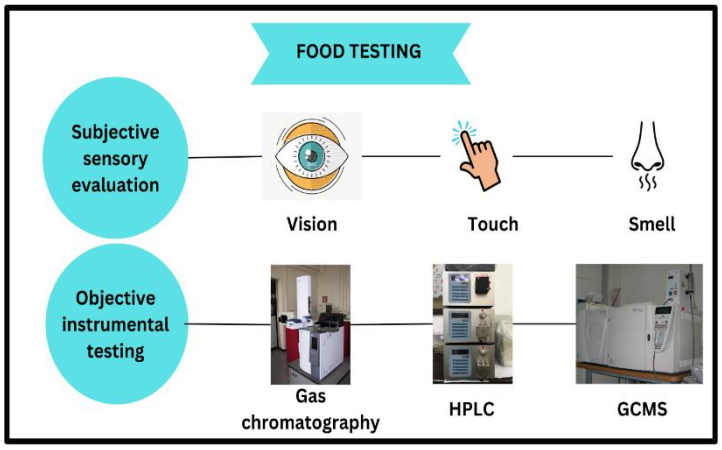
Keywords: Electronic Nose, Food Analysis, Food Quality, Food Safety, Sensor, Olfactory System

Introduction

Food is intrinsically linked to human existence. Without food, there is no life in our world. The world's population is growing at a rapid rate, which has increased demand for food and fuelled the food industry's explosive rise. The need for food has changed significantly as the times have changed. Today's food sector faces numerous crucial challenges, such as food safety and authenticity, real-time monitoring during food processing, food quality evaluation, food flavour evaluation, and origin traceability. Food testing technology is inextricably linked to people's increased attention to food safety, health, composition, brand, origin, and processing method. The electronic nose (E-nose) is one of the various food inspection technologies available today.

Food testing

Subjective sensory evaluation and objective instrumental testing are the two methods used in food testing. The sensory evaluation method needs professional training and it will become difficult to form objective evaluations. Standard techniques of instrumental testing are characterised by high costs and time-consuming challenges. Therefore, a quick, efficient, and inexpensive testing technique is desperately needed for food testing. E-nose is a promising device that has been successfully used in many facets of the food business and has produced encouraging results.



History of E-nose

Wilkens and Hartman invented E-nose research in 1964 when they used redox reactions on electrodes to electronically simulate an organism's olfactory process for the first time. In 1982, Persaud and Dodd published the first description of the E-nose. Research on E-noses had entered a phase of development since NATO's first theme forum on the topic was conducted in Iceland in August 1991. The word "E-nose" was first used in the late 1980s, but the concept was not publicly introduced until 1994, when Gardner and Bartlett released a review paper on the E-nose, which also signalled the rapid advancement of E-nose technology.

E-nose

Electronic nose (E-nose) is a quick, effective and non-destructive method. According to Martin (1975), an electronic nose is a device that analyses gaseous samples, particularly volatile substances by using a change in colour or a polymer's conductivity. It is "an instrument, which comprises an array of electronic chemical sensors with partial specificity and an appropriate pattern-recognition system, capable of recognising simple or complex odours," according to Gardner and Bartlett (1994). The E-nose is a novel bionic

detecting device that can identify, analyse, and detect a variety of gases and odours while simulating the process of human olfaction. E-nose measures the number of volatile substances and odours in food, similar to what human smell receptors can detect. Fast detection, short response times, and inexpensive costs are the hallmarks of e-noses.

Parts of E-nose

a) Gas sensor array
b) Sampling system
c) Data acquisition system
d) Data processing method

Gas sensor array

The gas sensor array constitutes the fundamental component of the electronic nose, comprising metal oxide sensors (MOS), metal–oxide–semiconductor field-effect transistor (MOSFET) sensors, conductive polymer sensors, piezoelectric sensors, and various other chemical sensors. MOS is the most widely used sensor among them. According to physiological research, numerous olfactory neurones sense each odorant, and a single olfactory neurone reacts to multiple odorants. In order to replicate the human olfactory system, the electronic nose decides to employ a sensor array made up of several distinct sensors. It is capable of reacting to the majority of volatile substances found in odour samples.

Sampling system

The sampling system is a key component in ensuring that samples are processed by the E-nose device. Its main purpose is to feed the E-nose detection system with the volatile substances found in the sample's headspace (HS). Choosing the right sampling system can enhance the detection system's analytical capabilities in addition to increasing sampling efficiency for various sample kinds, characteristics, and experimental objectives.

Data acquisition system

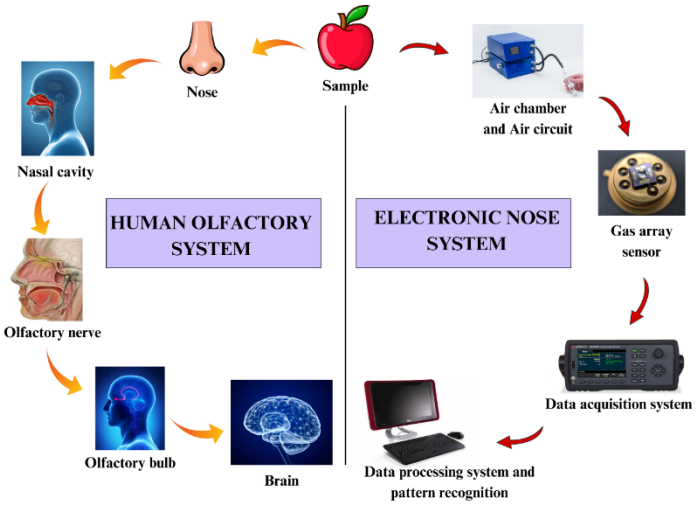
An essential component of the E-nose system's data processing and transmission is the data acquisition (DAQ) system. The E-nose instrument's sensors interact with the sample volatiles to cause chemical changes; the interface circuit is in charge of directly receiving the raw signal and translating the sensor response into electrical signals like voltage and current; and the DAQ input port is connected to the sensor output.

Data processing method

The sampling system of the E-nose system gathers the sample's volatile components. They are moved to the gas chamber via the gas channel, where they react chemically on the sensor's surface to provide a natural response when they come into touch with the room's sensor array. After being transformed into electrical signal data that a computer can process, the natural response is fed into the data gathering system. The gathered data is then processed and examined using the proper data processing techniques.

Comparison of the structure of the E-nose system and the human olfactory system is given below

Applications



First and foremost, the electronic nose is quite useful for detecting odours, including those of wine, vegetables, cigarettes, etc. It is extensively utilised in quality signing, odour detection, raw material inspection, and sprinkling process management. It is among the most important instruments for quality control and assurance. In fruit and vegetable testing, the electronic nose is mostly utilised for species identification, maturity detection, and quality assessment. A promising method for assessing the quality of poultry meat was the electronic nose, according to Boothe and Arnold (2002). Human sniffers are unable to identify dangerous or deadly gases, but the electronic nose can. Among the food business, the wine sector is undoubtedly one of the most willing to create sensors that resemble human senses. Evaluating wine using human sensibility is not new. Enabling a technical shift towards the application of novel analytical techniques, like sensor-based methodologies, is of increasing importance in the wine business. In this regard, non-destructive tools like NIR

spectroscopy and E-nose are increasingly being used for a variety of applications outside of the lab. Process inspection, freshness inspection, production analysis, and other fields all make extensive use of electronic noses. Recent developments in e-noses in the food business, with an emphasis on the most recent findings in six application areas quality control, pesticide residue detection, freshness assessment, process monitoring, flavour evaluation, authenticity evaluation, and origin tracing. Some of the commercial E-nose instruments used in food business are PEN3, FOX 3000/4000, Bloodhound BH114, EOS 507/835, Heracles II, AromaScan A32S, Cyranose 320, zNose 4200/4300/4500/7100 and Smart Nose 300. Some specific applications of e-noses in different foods are given in the table.

Food	E-nose Type	Application
Meat	PEN 3	To determine the total volatile alkaline nitrogen in mutton and to check the quality of fish meat
Dairy Product	Lab made	To categorize the different types of cheese
Coffee	Fox 3000	To detect the coffee bean volatile components and taste characteristics
Tea	PEN 3 and Heracles II	To detect the aroma quality of 44 kinds of Dianhong black tea (DBT) brewed tea Chen *et al*. (2022).
Fruit	PEN 3	Five apple varieties were evaluated for flavor difference and other quality indicators Zhu *et al*. (2020).
Jasmine	Hand held e-nose (HEN)	Aroma profiling of jasmine (*Jasminum sambac* Ait.) flowers using electronic nose technology Isac *et al*. (2016).

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Conclusion

Without a doubt, flavour analysis has steadily gained popularity in food science studies. Production line monitoring, adulteration identification, maturity detection, and food classification are just a few of the numerous applications for food flavour detection systems. The electronic nose is commonly used to classify foods based on their overall flavour profile. The system is low-cost and easy to use, with the ability to continually identify characteristics suited for industrial applications without the need for pretreatment. E-noses can detect and analyse food qualities, overcome external interferences, and provide real-time monitoring of growth and processing. Fast and accurate identification and analysis make it the chosen testing technique for the future food sector.

Reference

Alfieri, G., Modesti, M., Riggi, R., & Bellincontro, A. (2024). Recent Advances and Future Perspectives in the E-Nose Technologies Addressed to the Wine Industry. *Sensors*, *24*(7), 2293.

Isac, X. A., Rajadurai, K. R., Jawaharlal, M., Selvan, K., Uma, D., Roy, H., & Bhattacharyya, N. (2016). Aroma profiling of jasmine (Jasminum sambac Ait.) flowers using electronic nose technology. *Journal of Applied Horticulture*, *18*(1).

Mahanti, N. K., Shivashankar, S., Chhetri, K. B., Kumar, A., Rao, B. B., Aravind, J., & Swami, D. V. (2024). Enhancing Food Authentication through E-Nose and E-Tongue Technologies: Current Trends and Future Directions. *Trends in Food Science & Technology*, 104574.

Wang, M., & Chen, Y. (2024). Electronic nose and its application in the food industry: a review. *European Food Research and Technology*, *250*(1), 21-67.

Wei, G., Dan, M., Zhao, G., & Wang, D. (2023). Recent advances in chromatography-mass spectrometry and electronic nose technology in food flavor analysis and detection. Food Chemistry, 405, 134814.

Zhu, D., Ren, X., Wei, L., Cao, X., Ge, Y., Liu, H., & Li, J. (2020). Collaborative analysis on difference of apple fruits flavour using electronic nose and electronic tongue. *Scientia Horticulturae, 260*, Article 108879.