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Electronic nose and their application in food industries

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The feeling of smell and taste coming from specific and non specific atomic structures can be utilized to analyze the nature of food, drinks, and mixture of food items. Biological nose works actively to detect the quality of foods. We, as human being can use our nose to judge the quality of food by the odor coming out of food whether it is healthy or unhealthy. But still there is probability of making a mistake to judge the quality and to categorize the food. So the researchers feel a need to design an electronic system which can judge quality of food accurately and precisely. Electronic noses are making out of strong sensors arrays to sense the smell of food products. Comparing with the other artificial olfactory and gustatory techniques, traditional electronic nose are superior in some aspects, e.g., low cost, rapid detection, and convenient operation.In this paper literature is reviewed about the sensation of smell and taste and how electronic nose is useful for food industry .Biological nose and electronic nose are compared in this paper .various sensor system used in electronic noses are also explained.Further conclusion and further scope also discussed.

Key Words : Electronic nose, Receptors, Bio-nose, Sensors

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INTRODUCTION

The vibes of smell and taste coming about because of a progression of particular and nonspecific sub-atomic acknowledgment can be utilized as an explanatory apparatus as a part of numerous enterprises to quantify the nature of nourishment, beverages, and substance items. In some cases, there are olfactory receptors that are particular for individual synthetic atoms. Most tastes and odorants are distinguished through an amalgamation of the worldwide data from nonspecific collaborations. Taking mammalian gustation for instance, the blend of "gustatory buds" which react to five taste classes: pungent, sweet, biting, salty and umami makes a difference for each taste. To imitate the nonspecific acknowledgment, customary electronic noses that are made out of strong state sensors cluster were created. The sense of smell and taste are connected through various transduction system. In this paper, we reviewed the work done over the previous years to make an electronic nose, and its application in food industry.

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Traditional electronic nose :

An accepted definition of an electronic nose is "an instrument which comprises an array of electronic chemical sensors with partial specificity and an appropriate pattern recognition system, capable of recognizing simple or complex odor" (Gardner and Bartlett, 1999) and tries to distinguish dissimilar gas mixtures. Comparing with other methods of analysis, electronic nose frameworks are easy to manufacture and provides results efficiently. The focus of present study concentrates on the detecting strategies utilized in traditional electronic noses.

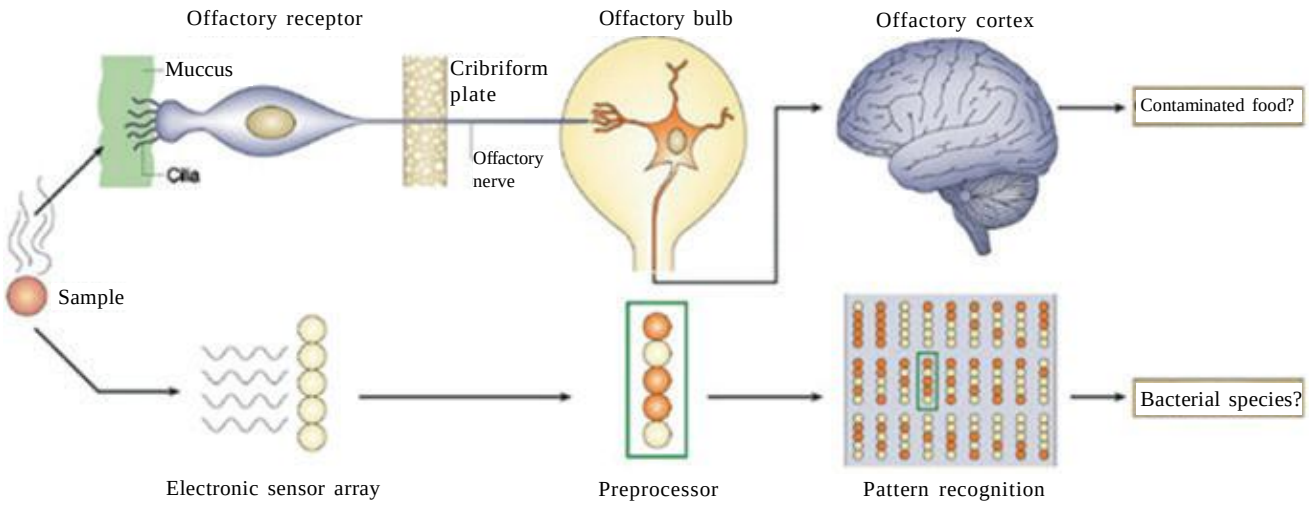

Fig. 1 : A comparison of a biological nose with electronic nose (Turner and Magan, 2004).

Principle and structure :

Discussion is incomplete without comparison of electronic nose without organic nose. Fig 1 shows a comparison of a biological nose with electronic nose. In case of natural nose, mucous and vibrissae in nasal hole execute filtration process and grouping of odorant particles. Odorant particles are conveyed to the olfactory epithelium due to heavy pressure supplied by the lungs. Olfactory epithelium contains a huge number of detecting cells and olfactory receptors are situated on the layers of these cells. Receptors change these chemical signals into electroneurographic signals.

A particular pattern of electroneurographic signals is translated by olfactory cortex neural system. Based on the same principle electronic noses are designed in which pumps are replaced by lungs and the inlet examination system designed in form of electronic sensor array replaced mucous and the signals goes to preprocessor in the same way as in olfactory receptors and a pattern recognition is done on the pattern of olfactory cortex neural system .

Electronic nose are utilized to describe diverse gas blends and also natural nose. Be that as it may, there still exist some crucial contrasts in both equipment and programming. Points of interest of correlations between these two “noses” are recorded underneath (Table 1).In rundown, an electronic nose is made out of two principle parts: detecting framework and sign handling framework. They are examined in the accompanying areas, separately

Sensing system :

Electronic sensing also called e-sensing refers to reproducing human senses using sensor arrays, emerged as a technical tool in quality control in food sector as well as important from commercial point of view. The International Union of Pure and Applied Chemistry (IUPAC) characterize synthetic sensors as “gadgets that transform chemical data into the form which can be further analyzed. Variety of sensors are available for the analysis of food as they have their own advantages and disadvantages because of change in structural configuration in terms of input variable, working temperature and lifetime. Statistical programme are used to classify the samples into the groups for further analysis (Ampuero and Bosset, 2003).

Sensor innovation has grown quickly over the previous decade, and this has brought about a scope of various sensor groups and the advancement of complex microarray sensor gadgets. The most usually utilized sensors incorporate metal oxide semiconductor (MOS) sensors, conducting polymer (CP) sensors, optical sensors and piezoelectric sensors.

Metal-oxide sensors :

Metal-oxide sensors, also called semiconductor metal-oxide sensors, comprise of a bearer like ceramics,

Table 1 : Comparing electronic nose with human nose Bio-nose

Bio- nose	Electronic nose
It uses the lungs to bring the odor to epithelium layer	It employs a pump to smell the odor
It has mucus, membrane, and hair to act as filter	It has an inlet sampling system that provides filtration
The human nose contains the olfactory epithelium, which contains millions of sensing cells that interact with odorants in unique	Electronic nose has a variety of sensors that interact differently with a group of odorous molecules
The human receptors convert the chemical response to electronic nerve impulses whose unique patterns are propagated by neurons through a complex network before reaching the higher brain for interpretation	Similarly, the chemical sensors in the electronic nose react with the sample and produce electrical signals. A computer reads the unique pattern of signals and interprets them with some form of intelligent pattern classification algorithms

silicon and a metal-oxide film (tin, zinc, titanium, iron, cobalt, nickel). They comes under the classification of electrical sensors. Amid the estimation procedure, volatile organic compounds (VOCs) and gas particles are adsorbed by the metal-oxide film, subsequently changing its electrical resistance. This change is deciphered into a sign. The adjustment in resistance relies on upon the VOC interfacing with the desorbed O_2 on the semiconductor and in addition the metal oxide. This experience was initially exhibited utilizing zinc oxide (ZnO) film layers. As per the results obtained from ZnO, further metal oxides were inspected because their conductivity varies due to gas atmosphere around them, including ZnO (Ahn *et al.*, 2008 and Bie *et al.*, 2007), WO_3 (Waitz *et al.*, 2008 and Li *et al.*, 2004), SiO_2 (Kang and Kim, 1993 and Arbab *et al.*, 1993) and TiO_2 (Karunagaran *et al.*, 2007 and Mor *et al.*, 2004).

Polymer sensors :

Polymer sensors comes under the classification of electrical sensors, are made of conductive plastics that adsorb VOCs and gas atoms. They have ability to respond to the organic compounds and adjust their conductivity accordingly. Effective uses of leading polymers to electronic noses as sensor components have been led in a few articles (Bartlett and Ling-Chung, 1989 and Ridgway *et al.*, 1999). They are preferred due to wide selectivity, high sensitivity and low working temperature. They have some drawbacks for example they are very reactive to hydrogen that can alter the results.

Optical sensors :

Optical sensors are used as gas sensors in many applications shows good response for accurate measurement (Lippitsch *et al.*, 1988; Posch and Wolfbeis, 1989 and Gehrich *et al.*, 1986). These are mainly based on source of light which give the movement to volatile molecules and measurement of signal done in form of absorbance, reflectance and fluorescence. Such output signals are detected using various detectors (Johnson *et al.*, 1997 and Chodavarapu *et al.*, 2007).

Piezoelectric sensors :

Piezoelectric sensors have a radio frequency resonance under such electric potential and are highly sensitive to the mass change applied to the surfaces of piezoelectric sensors. Quartz crystal microbalance (QCM) and surface acoustic wave (SAW) sensors are two of the most useful piezoelectric sensors applied in electronic noses.

Other sensors :

Different sorts of sensor incorporate MOSFETs (metal-oxide-semiconductor field-effect transistors) are similar to polymer sensors. They are classified as electrical sensors and 'quartz microbalance' or QMB2 sensors.

Applications of electronic noses in the food industry:

In the past, electronic noses have been developed for the classification and recognition of a large variety of foods. Some applications of electronic nose in food industry are discussed here.

Beer:

E-nose is used for the classification of the beer samples and also highlights the compound that makes the major differences. Sensor-based electronic noses are employed to identify efficient technology to make different types of beers (Pearce *et al.*, 1993 and Ghasemi-Varnamkhasti *et al.*, 2011). Gas chromatography -ion-mobility spectrometry (GC-IMS) based electronic nose framework is used to monitor the brewing process and

to measure concentrations of diacetyl and pentanedione – products of beer fermentation.

Fish:

Odor of fish is important quality parameter on basis of it is accepted or rejected. Usually, quality of fish and fish products has been done on basis of sensory or by gas chromatography. So there is need for development of an efficient technique to control the quality of fish and fish products. Electronic noses plays important role by providing rapid, automated and objective tools for quality control of fish and fish by products Electronic noses have been utilized to distinguish waste of cod by means of the marker trimethylamine (O'Connell *et al.*, 2001 and Winquist *et al.*, 1995).

Meat:

Electronic noses have been used to test the shelf life (Winquist *et al.*, 1993 and Rajamaki *et al.*, 2006) of roast chickens packed in a modified atmosphere and to compare the results with those of microbiological and sensory analysis and gas chromatography. A high correlation was shown between the results given by the microbiological analysis and those obtained from the electronic nose.

Oil:

Electronic noses are very useful to detect of aroma of olive oil and to check the originality of olive oil .Quality parameters of olive oil is influenced by geographical location, selection of olive seed and farming method. An electronic nose also helpful for assessment of the degree of oxidation in edible oils.

Fruit:

Fruits are source of volatile components that impart their characteristically distinct aromas and provide unique flavor characteristics. Fruit aroma and flavour characteristics are of key importance in determining consumer acceptance in commercial fruit markets based on individual preference change during ripening of fruits is also monitored with help of electronic nose. Quality of fruits can be analyzed by electronic nose by detecting the flavor changes during ripening process (Saevels *et al.*, 2004 and Zhang *et al.*, 2008). To do this, an electronic nose's sensors were covered with a specific material that helps to detect maturing. Utilizing this approach, it was conceivable to order apples in view of their readiness. With the help of the electronic noses it is easy to find out the storage period after harvesting.

Tea :

As reported by (Arshak *et al.*, 2006), an examination about use of electronic nose was conducted in refinement of tea quality.

Conclusion and future scope :

Electronic nose has a promising potential for rapid non-destructive analysis of food quality. It may be applicable in quality control of raw material, food processing or products. Electronic nose cannot completely replace reference methods like the use of sensory panels, as they require a frequent calibration against some valid reference method. Electronic noses faced difficulty regarding handling of samples and performance of instrument. An instrumental extension in electronic noses by putting research efforts in which it may become friendly with handling and monitoring of all food samples in an accurate way.

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