A Novel Technique to Preserve Nourishment of Food Beverages using E-Nose Technology in Food Industry

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Abstract— The food industry is very essential to full-fill the needs, not only the customers but also to the food lovers. Farmers harvest the food products but unable to keep the items always fresh and eatable. So in this case the food industries play a vital role to enrich them. They follow different strategies to keep each and every products fresh and best to reach the consumers by some familiar methods like preserving, Refrigerating, etc. To handle all these things automatically high level of automation is required because food products can vary in size, shape, fragrance, colour etc. Considering these diversity factors in this food industry, it is almost impossible to obtain a generic automation solution. Automated systems in food production come in different functions and sizes, very much depending on the food item and specific requirements of the customers or consumers. Hence, Electronics play very important role for automation in food industry. This paper gives the idea about the role of E-Nose in food industry. E-noses are the systems for the automated detection and classification of odours, vapours and gases, which have provided an excess of benefits to the agricultural, pharmaceutical, environmental, biomedical, cosmetics, food, manufacturing, military and various scientific research fields. An E-nose is generally composed of a chemical sensing system and a pattern recognition system. The recognition pattern in E-nose is used to determine one sample from another is based on headspace volatiles. This innovative technique used to improved product attributes, uniformity, and consistency which results in quality control capabilities afforded in all phases of food industries to keep the food items always fresh.

Keywords: E-Nose, Sensors, Biological Nose

I. INTRODUCTION

Managing aromatic properties in food production plays a vital role in assessing the product to ensure its acceptability. Moreover, it can be a component of product design by utilizing consumer expectations before a product is completed. At the end of the production process, the product must be acceptable to the consumer. The aromatic properties of foodstuff depend on many chemicals that give the food character and unique qualities. Reliably identifying and measuring the optimum flavour and its characteristics are ongoing critical tasks in the development of new products. So called odor experts have typically been responsible for this challenging task. However, the individual judgments of these experts inevitably include subjective factors of personal preferences. To avoid this subjectivity, the e-nose can instead be used.

Measurements made with the e-nose are objective, reproducible, reliable, and relatively inexpensive. E-nose interpretation is simple, fast, and can be performed in real time. As with the human nose, the e-nose learns by experience and improves its capabilities. It is designed to analyze, recognize, and identify very low levels (parts per billion) of volatile chemicals. The technology is based on absorption and desorption of volatile chemicals traversing a sensor array. This translates to specific changes in electrical resistance measurable at each sensor element when sensors are exposed to different flavours and odors. Recent research confirmed the possibility of developing e-noses for new product development in the food industry.

II. WORKING PRINCIPLE

An e-nose can be seen as an array of sensors able to generate an electronic signal in response to simple or complex Volatile aroma compounds present in the gaseous sample. Electronic Nose consists of three major parts 1. SAMPLE DELIVERY SYSTEM, which enables generation of volatile aroma compounds from headspace of a sample which is injected into the detection system. 2. DETECTION SYSTEM, which consists of a sensor (essentially a transducer) and a converter. Volatile aroma compounds are adsorbed on the sensor surface which changes the physical properties of the sensor thus changing the electrical properties. The response is recorded & transformed the signal into a digital value. 3. COMPUTING SYSTEM, which records data computed on the basis of a statistical model.

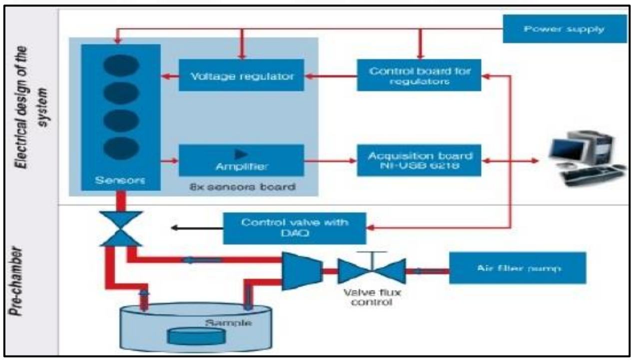

Fig. 1: E-Nose System Design

A. *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. 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.

B. Computing System:

The interpretation of the complex data sets from e-nose signals is accomplished by use of multivariate statistics. These signals often divided into two parts: training set and test set. Training sets of data are used to build classification models, while test sets of data are used to evaluate the classification model. These including principal component analyses such as (PCA), linear discriminant analysis (LDA), discriminant function analysis (DFA), hierarchical cluster analysis (HCA), soft independent modeling of class analogy (SIMCA) and partial least squares (PLS). For non-linear responses, artificial neural networks (NAA) can be used for modeling the data.

III. TYPES OF SENSORS

A. Metal-oxide sensors:

Metal-oxide sensors, also called semiconductor metal-oxide sensors, comprise of a bearer like ceramics, silicon and a metal-oxide film (tin, zinc, titanium, iron, cobalt, nickel). They come 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 O2 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, WO3, SiO2 and TiO2.

Fig. 2: Metal Oxide Sensor

B. 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.

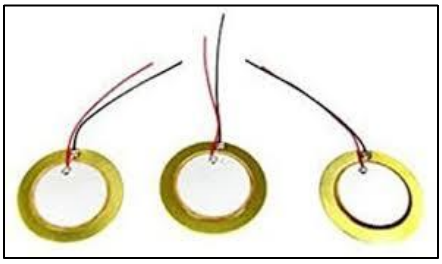

Fig. 3: Piezo Electric Sensor

C. Optical sensors:

Optical sensors are used as gas sensors in many applications shows good response for accurate measurement. 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.

Fig. 4: Optical Sensors

D. 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. They are preferred due to wide electivity, high sensitivity and low working temperature. They have some drawbacks for example they are very reactive to hydrogen that can alter the results.

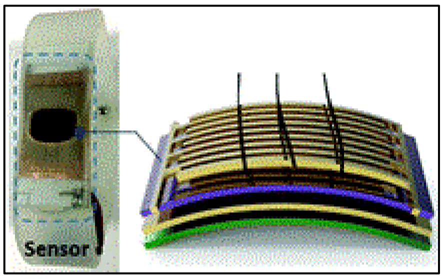

Fig. 5: Polymer Sensor

E. 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.

IV. COMPARISON OF E-NOSE WITH BIOLOGICAL NOSE

The standard 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.

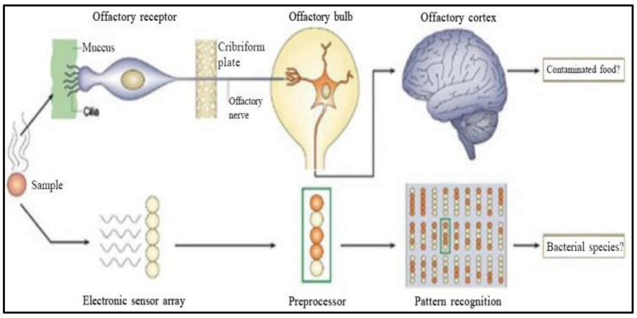

Fig. 6: Comparison of E-Nose with Biological Nose

Inhaling	Pump
Mucus	Filter
Olfactory epithelium	Sensors
Binding with proteins	Interaction
Enzymatic proteins	Reaction
Cell membrane depolarized	Signal
Nerve impulses	Circuitry & Artificial neural network

Table 1: Comparison table of E-nose with Biological Nose

V. APPLICATIONS OF E-NOSES IN THE FOOD INDUSTRY

- 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.
- 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 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.
- Fruits are source of volatile components that impart their characteristically distinct aromas and provide unique flavour 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. 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.

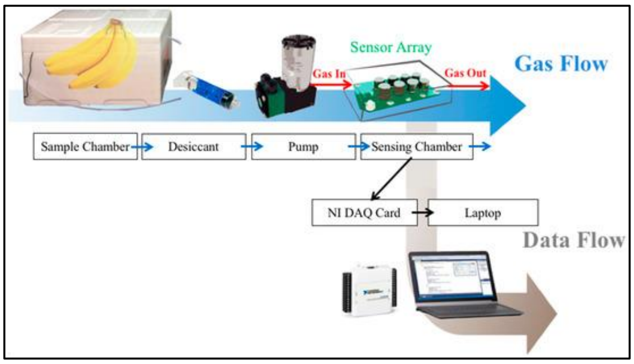

Fig. 7: E-Nose System for Analysing Aroma in Fruits

- For meat, the e-nose has been used to detect bacterial spoilage during the aging process using biosensors that included a silver or platinum electrode on which the enzymes putrescine or xanthine oxidases were immobilized.
- An e-nose could distinguish eggs stored for different amounts of time and at chilled or room temperature storage.
- An e-nose technique was optimized to classify wheat based on storage age.
- An ion-mobility based e-nose was used to determine separation of hard and extra-hard cheese samples as well as discrimination of cheeses based on age (ripening time) or origin.
- An e-nose with six metal oxide sensors was used to classify virgin olive oils with and without phenolic compounds for oxidative status and correlated well to sensory analysis.
- 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 Tri-methylamine.

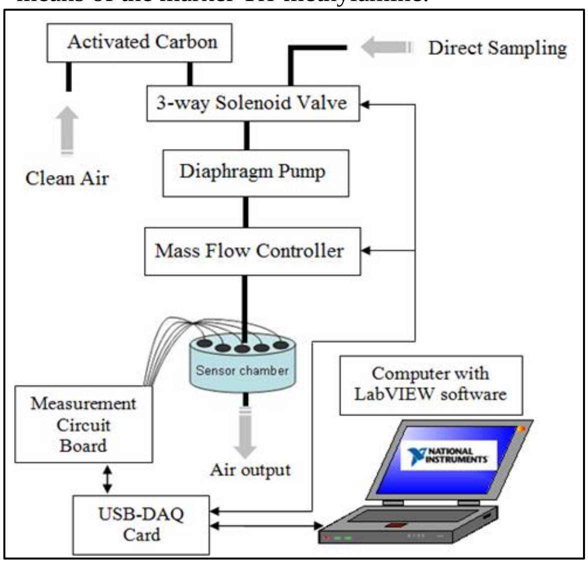

Fig. 8: E-Nose System for Fishing Industry

– An examination about use of electronic nose was conducted in refinement of tea quality.

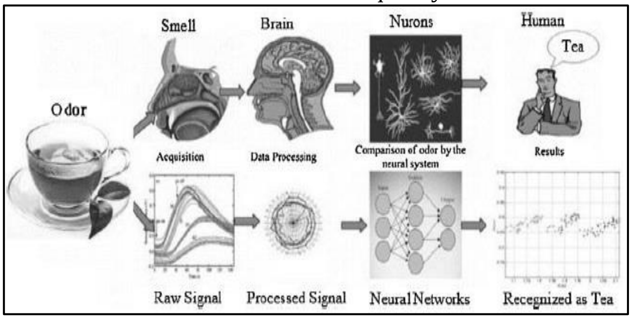

Fig. 9: E-Nose System in Tea Industry

– E-Nose also used in off-flavor or drinking water, in which Most waterborne bacteria are common and not dangerous to human health; however, they are responsible for some of the most problematic odor contaminations in potable water. One genus of bacteria commonly found in water supply networks is Pseudomonas. These bacteria are relatively ubiquitous on account of their simple nutritional requirements and ability to utilize many different organic compounds as energy sources. In fact, they can increase sulphur and selenium content, which results in off-odors usually described by associations to wet cloth, cockles, butane, rubber, or rotten eggs.

VI. CONCLUSION

In the era of modern technology, food industry is lagging behind due to uses of conventional methods to analyze the food product quality. So there is need for efficient biosensors and image processing techniques to provide rapid, economic, hygienic, consistent and objective assessment. So, Electronic nose has a promising potential for rapid non-destructive analysis of food quality. It may be applicable in quality control of food processing or products and raw materials. Electronic nose cannot completely replace reference methods like the use of sensory panels, as they require a frequent calibration against some valid reference method. The development of artificial senses technologies is occurring rapidly, with demonstrated ability to differentiate among food and edible products for bitterness, aroma and other basic tastes. Basically, it is a tool provided to overcome the shortcomings of human nose, thus giving more fast & accurate result.

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