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USEFULNESS AND APPLICATIONS OF SENSING SYSTEM IN FOOD INDUSTRY

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ABSTRACT:

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 analysed. 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. The electronic nose, tongue, and eye are futuristic technologies that have been usedfor many years; they have been gaining market in different types of industries and can increasingly befound in the food area; their function is to determine sensory characteristics (smell, aroma, and flavour)and objective visuals, without the subjectivity that can be represented by sensory analysis by people (thestudy that can complement the analysis of machines, without being exclusive).The feeling of smell and taste coming from specific and non-specific atomic structures can be utilized to analyse the natureof food, drinks, and mixture of food items. Biological nose works actively to detect the quality of foods. We, as humanbeing can use our nose to judge the quality of food by the odor coming out of food whether it is healthy or unhealthy. Butstill there is probability of making a mistake to judge the quality and to categorize the food. So the researchers feel a needto design an electronic system which can judge quality of food

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accurately and precisely. Electronic noses are making outof strong sensors arrays to sense the smell of food products.

INTRODUCTION:

Objectives: Find the maingeneralities of these mechanisms, their sensors, software, mechanism of action, and applications within thefood industry.

Methods: A search was carried out in the main databases of indexed articles, with termsthat allowed collecting the necessary information, and 89 articles were used that met different inclusioncriteria.

Results: The main outcomes were to understand the operation of each of these technologies, what their main components are, and how they can be linked in the beer, wine, oil, fruit, vegetable,dairy, etc. industry to determine their quality, safety, and fraud.

Conclusions: The use of electronicnose, tongue, and eye is found in more food industries every day. Its technology continues to evolve; thefuture of sensory analysis will undoubtedly apply these mechanisms due to the reliability, speed, andreproducibility of the results.

APPLICATIONS OF ELECTRONIC NOSES IN THE FOOD INDUSTRY:

Following are some applications of e-nose in food industry.

1. An e-nose technique was optimized to classify wheat based on storage age.
2. 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.
3. An e-nose could distinguish eggs stored for different amounts of time and at chilled or room temperature storage.
4. 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.
5. 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 putrescence or xanthine oxidases were immobilized.
6. 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,

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automated and objective tools for quality control of fish ,For fish, freshness was determined by measuring the relevant volatile compounds consisting of alcohols, carbonyls, amines and mercaptanes which showed typical concentration changes over time under specific storage conditions.

7. 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.

8. 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.

9. 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.

USE OF ELECTRONIC TONGUE [E-TONGUE]

The e-tongue is an instrument that measures and compares tastes. E-tongue was designed to minimize human olfactory and taste sensory organs and are consisted of an array of sensors. Various efforts have been made by scientists to predict the sensory profile of food articles with instrumental measurement. The e-tongue uses taste sensors to receive information from chemicals on the tongue and send it to a pattern recognition system. The result is the detection of the tastes that compose the human palate. The types of taste that is generated is divided into five categories sourness, saltiness, bitterness, sweetness, and umami(savouriness). Sourness, which includes hydrogen chloride, acetic acid, and citric acid, is created by hydrogen ions. Saltiness is registered as sodium chloride, sweetness by sugars, bitterness, which includes chemicals such as quinine and caffeine is detected through magnesium chloride and umami by monosodium glutamate from seaweed, or disodium guan late in meat/fish/mushrooms. The aim of the review here is to determine the applicability of e-tongue in food industry to replace traditional methods of sensory analysis. This review describes the basic principles and applications of e-tongues in the food industry. It explains

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the application of e-tongues to eliminate panellist bias for taste evaluation of food products. The evaluation of dairy and food products for their organoleptic properties is one of the essential requirements for the development of newer items as well as their perfection at the stage of production or marketing. In the era of sensor technology, the evolution of e-tongues has initiated renaissance in sensory assessment of foods. This paper covers the structure and main principle along with the detection systems used in the e-tongue development. The main elements of an electronic taste-sensing system are number of different sensor types attached to arm, a sample table, an amplifier, and a computer for data recording. This system imitates what is happening when molecules with specific taste nature interact with taste buds on the human tongue. The taste buds are represented by sensors which interact with these molecules at the surface initiating changes in potential. These signals are compared with physiological action potentials which are recorded by computer, which correspond to the neural network at the physiological level. The data obtained can further be evaluated on the basis of already existing matrix of sensor responses which can be compared with human memory or association to already existing taste patterns.

PRINCIPLE AND STRUCTURE:

Discussion is incomplete without comparison ofelectronic nose without organic nose. Fig 1 shows acomparison of a biological nose with electronic nose. Incase of natural nose, mucous and vibrissae in nasal holeexecute filtration process and grouping of odorantparticles. Odorant particles are conveyed to the olfactoryepithelium due to heavy pressure supplied by the lungs.Olfactory epithelium contains a huge number of detectingcells and olfactory receptors are situated on the layers ofthese cells. Receptors change these chemical signals into electroneurographic signals. A particular pattern of electroneurographic signals is translated by olfactory cortex neural system. Basedon the same principle electronic noses are designed inwhich pumps are replaced by lungs and the inletexamination system designed in form of electronic sensorarray replaced mucous and the signals goes topre-processor in the same way as in olfactory receptorsand a pattern recognition is done on the pattern of olfactory cortex neural system. Electronic nose are utilized to describe diverse gasblends and also natural nose. Be that as it may, there stillexist some crucial contrasts in both equipment andprogramming. Points of interest of correlations betweenthese two “noses” are recorded underneath. Inrundown, an electronic nose is made out of two principleparts: detecting

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framework and sign handling framework.They are examined in the accompanying areas, separately.

SENSING SYSTEM:

Electronic sensing also called e-sensing refers toreproducing human senses using sensor arrays, emergedas a technical tool in quality control in food sector as wellas important from commercial point of view. TheInternational Union of Pure and Applied Chemistry(IUPAC) characterize synthetic sensors as “gadgets thattransform chemical data into the form which can befurther analysed. Variety of sensors is available for theanalysis of food as they have their own advantages anddisadvantages because of change in structuralconfiguration in terms of input variable, workingtemperature and lifetime. Statistical programme are usedto classify the samples into the groups for further analysis(Ampuero and Bosset, 2003).Sensor innovation has grown quickly over theprevious decade, and this has brought about a scope ofvarious sensor groups and the advancement of complexmicroarray sensor gadgets. The most usually utilizedsensors incorporate metal oxide semiconductor (MOS)sensors, conducting polymer (CP) sensors, optical sensorsand piezoelectric sensors.

Metal-oxide sensors:

Metal-oxide sensors, also called semiconductormetal-oxide sensors, comprise of a bearer like ceramics,silicon and a metal-oxide film (tin, zinc, titanium, iron, cobalt, and nickel). They come under the classification ofelectrical sensors. Amid the estimation procedure, volatileorganic compounds (VOCs) and gas particles areadsorbed by the metal-oxide film, subsequently changingits electrical resistance. This change is deciphered into asign. The adjustment in resistance relies on upon the VOCinterfacing with the desorbed O2 on the semiconductorand in addition the metal oxide. This experience wasinitially exhibited utilizing zinc oxide (ZnO) film layers.

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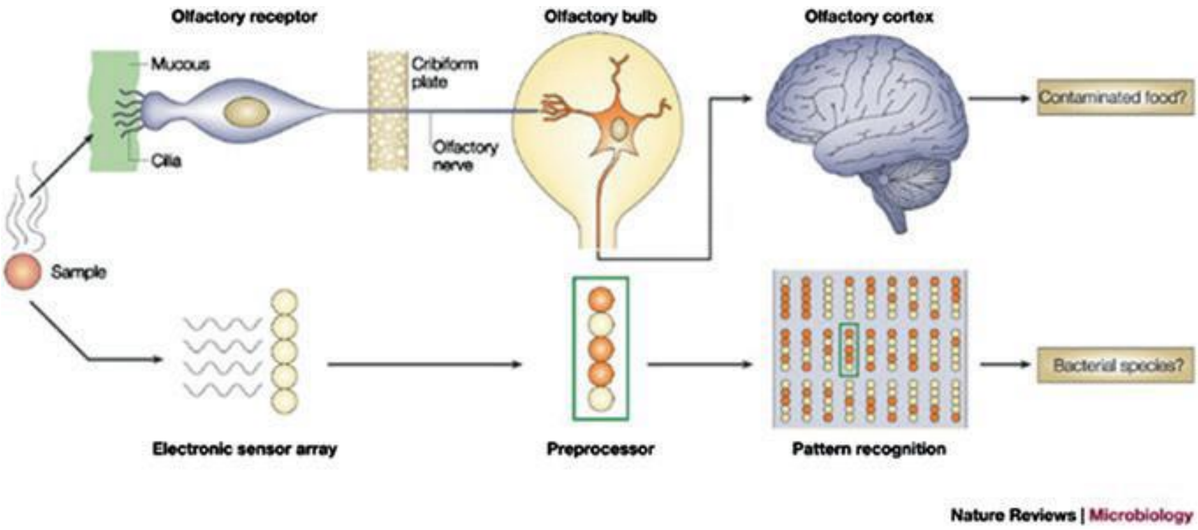

Fig. 1 : A comparison of a biological nose with electronic nose (Turner and Magan, 2004).

Polymer sensors:

Polymer sensors comes under the classification ofelectrical sensors, are made of conductive plastics thatadsorb VOCs and gas atoms. They have ability to respondto the organic compounds and adjust their conductivityaccordingly. Effective uses of leading polymers toelectronic noses as sensor components have been led ina few articles (Bartlett and Ling-Chung, 1989 andRidgway et al., 1999). They are preferred due to wideselectivity, high sensitivity and low working temperature.They have some drawbacks for example they are veryreactive to hydrogen that can alter the results.

Optical sensors:

Optical sensors are used as gas sensors in manyapplications shows good response for accurate measurement (Lippitsch et al., 1988; Posch and Wolfbeis,1989 and Gehrichet al., 1986). These are mainly basedon source of light which give the movement to volatilemolecules and measurement of signal done in form ofabsorbance, reflectance and fluorescence. Such outputsignals are detected using various detectors (Johnson etal., 1997 and Chodavarapu et al., 2007).

Piezoelectric sensors:

Piezoelectric sensors have a radio frequencyresonance under such electric potential and are highlysensitive to the mass change applied to the surfaces ofpiezoelectric sensors. Quartz crystal microbalance(QCM) and surface acoustic wave (SAW) sensors aretwo of the most useful piezoelectric sensors applied inelectronic noses.

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Other sensors:

Different sorts of sensor incorporate MOSFETs(metal-oxide-semiconductor field-effect transistors) aresimilar to polymer sensors. They are classified aselectrical sensors and 'quartz microbalance' or QMB2sensors.

ELECTRONIC TONGUE

The human sense of taste involves identifyingbasic flavours, including sweetness, acidity, bitterness,salinity, and umami. The human sensory panel(trained or untrained) has been used to performtaste evaluations on many food products, yetrunning and training people is relatively time-consumingand expensive. In some cases, sensorypanels can introduce bias if the panellists are notwell trained; thus, many researchers have used theelectronic tongue as a rapid and impartial detectionalternative to the human tongue. The electronic tongue is a multi-channel tastesensor (more than five basic flavours) with globalselectivity. It is composed of several types of lipid/polymer membranes to transform informationabout taste substances into electrical signals uploaded into a computer. Electronic tonguesignals are analysed in a pattern recognition unitto discriminate between similar samples. It is ananalytical tool composed of three parts: (1) nonspecificand not very selective chemical sensorsthat have partial specificity (cross-sensitivity) todifferent components in a liquid sample; (2) anappropriate method of pattern recognition; (3)multivariate calibration for data processing. By decoding the chemical energy of the interactionbetween the detection unit and the analyses intoa primary signal output, the array of detectionelements determines the entire analytical system'sperformance. Electronic tongue instrumentsdepend on available analytical technologies thatoperate in the liquid phase. The most commonare based on electrochemical techniques such asvoltammetry, potentiometry, and conductometry, which require electrodes in the liquid phase toestablish a measurement circuit.

ELECTRONIC EYE

An electronic eye is a computer vision technologythat converts optical images into digital images. Ituses an image sensor instead of the human eyeto collect images of objects and uses computersimulation criteria to identify the images to avoidsubjective deviation of human vision. Thecomputer vision process generally includes fivesteps: image acquisition, image processing, featureextraction, pattern recognition, and decisionmaking. All steps are

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sequential and could beexpressed as a simple flow chart. Decision-makingrules are a part of the control system that includes apre-established set of rules, formalizing the controland optimization strategy. Computer vision is partof the intelligent control system; it could also includesupervised or unsupervised learning elements forpattern recognition, modelling, and knowledge basedevelopment. In this case, the set of rules could beadjusted, depending on the established interactionprocedure and the optimization criteria.

Hardware

Computer vision hardware generally consists of ahousing, a light source, a digital camera in color with an optical lens (the camera with a charge-coupleddevice is the most used in electronic eye designs),and a computer. In the case of multispectral orhyper spectral vision, a set of narrow-band opticalfilters (usually 10 nm) is also required. The designof the case, such as the geometry, the walls interior color, and the background, is fundamental to obtainhigh-quality images. One of the options for offlineimaging is flatbed scanners, which provide uniformillumination with good contrast and resolution.

Software

Recent versions of Windows have a set of driverscompatible with most imaging devices, allowingsimple image or video capture. This set of driversis specific to the Charge-Coupled Device (CCD)camera, interface, and software. However, thestandard Windows software functionality is notsufficient to adjust the settings of the CCD cameraor time-controlled image acquisition. Therefore,most CCD camera manufacturers usually supplyspecialized software designed for a particularcamera and interface, often leading to compatibilityissues. This is probably an explanation why mostresearchers still use two different software packages:one for image capture (which could be part of thecamera software) and another for offline imageprocessing and analysis. Measurement evaluation isperformed using software that creates colour spectraand applies multivariate principal componentanalysis (PCA) statistics for statistical analysis.

CONCLUSION:

In the era of modern technology, food industry is lagging behind due to uses of conventional methods to analyse the food product quality. So there is need for efficient biosensors and image processing techniques to provide rapid, economic, hygienic, consistent and objective

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assessment. The adoption of this emerging technology in improving quality inspection of food products will be of immense benefit for the food industry. Although, human tasters and sensory assessment of food cannot be substituted by an instrument, many studies have shown that e- tongue and e- nose poses as an excellent non-destructive method for the determination of both toxic and non-toxic food products. There is a wide variety of food products suchas vegetables, fruits, meat, seafood, etc. These foodproducts can be divided into very good, good, orbad categories in individual units. To handle all ofthese things automatically requires a high level ofautomation because food products can vary in size,shape, fragrance, colour, etc. Considering the foodindustry's diversity, it is almost impossible to comeup with a generic automation solution. Electronicsplay a critical role in automation in the foodindustry. Automated food production systems comein different functions and sizes, depending verymuch on the type of food and the manufacturers'specific requirements.An instrumental extension in electronic nosesby putting research efforts in which it may becomefriendly with handling and monitoring of all food samplesin an accurate way.

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