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E-Nose as a Detector of Adulteration in Cow Milk Ghee

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Abstract— In Indian culture Cow milk ghee is termed as most divine to be used in any rituals. And why not, its nutritional value is so great that it is used largely in Ayurveda medicines. Its health benefits – providing immunity power, bones strength, nutrition to brain, eye etc. makes it so important that it is astaple food in India. Pure cow milk ghee is prepared by a typical method,which make it very expensive. But this is also the fact that makes the food more prone to adulteration. Adulteration not only causes economic loss but also creates serious threat to the human health. The aim of this study was to detect the adulteration in cow milk ghee using an electronic nose(E-Nose). The cow milk ghee was cheated for different levels of adulteration by Dalda and Sunflower oil (20%, 40%, 60%, 80% adulteration). Volatiles generated during heating were sensed by the sensorsand changed their conductance level.Using the classifier the results were evaluated.IoT further enhanced the system by providing more transparency.
Keywords: Adulteration, Cow Milk Ghee, Electronic Nose.

I. INTRODUCTION

Cow milk ghee is prepared by both traditional and industrial methods. Traditionally Cow milk Ghee is prepared by converting the milk into curd first. This curd is then churned in clockwise and anticlockwise direction with a proper speed . Buttermilk and butter is separated from it. After that butter is heated up to a particular temperature to get a clarified butter called Pure Ghee. And this pure ghee is adulterated by adding vegetable oil, animal fat, and starchy material and so on[1].
“Adulteration is the process by which the quality or the nature of a given substance is reduced through the addition of a foreign substance and the removal of a vital element” [2]. The adulteration of high-quality ghee with cheap vegetable fat (like Dalda)or sunflower oil is a frequent problem from regulatory agencies,oil suppliers and consumers. Following are some methods have been proposed for the detection of adulteration in high quality oils such as

- High performance liquid chromatography (HPLC) [3],
- solid phase micro extraction gas chromatography-mass spectrometry (SPME-GC-MS) [4],
- Time of flight mass spectrometry (MALDI-TOF-MS) [5],
- Raman spectroscopy [6] ,
- Near infrared spectroscopy [7] ,
- Fluorescence [8] , and
- Nuclear magnetic resonance[9]
- Inductively Coupled plasma optical emission spectrometry (ICP-OES) [10] have been used.

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However, most of these techniques are usually time-consuming and expensive for routine use in food industry; hence there is a large demand for instant, economical, and effective techniques for food quality control and especially for food adulteration detection[12].

E-nose can detect and recognize odours with a high level of reliability. It uses number of electronic sensors due to which it can differentiate between volatile and non-volatile compounds used in the mixtures [12].

LITERATURESURVEY

FardinAyari et al. "Detection the adulteration in pure cow ghee by electronic nose method"[1] has presented the sensors that can be used for detection of adulteration in cow ghee. Here numerous sensors are used but the emphasis is given on MQ136 sensor which is a sulfur dioxide sensor.

Sensor No.	Sensor type	Main application	Detection ranges(ppm)
1	MQ-3	Alcohol	10-300
2	MQ-9	CO & Combustible gases	10-1000 & 100-10000
3	MQ-135	Steam ammonia, benzene, sulphide	10-10000
4	MQ-136	Sulphur dioxide	1-200
5	TGS-813	CH4, C3H8, C4H10	500-10000
6	TGS-822	Steam organic solvents	50-5000
7	TGS-2602	Sulphide ,hydrogen sulphide, ammonia , toluene	1-30
8	TGS-2620	Alcohol, steam organic solvents	50-5000

Table1: The used sensors in Electronic Nose

Note: The above Table 1 is from "Detection of the adulteration in pure cow ghee by electronic nose method"."International Journal of Food Properties ISSN No:-1094-2912 Aug–2018".

The heating method is used on adulterated samples of the cow ghee.Volatiles that are generated in the head spaceafter heating the samples which are detected by the gas sensors.These volatiles change the voltage of the gas sensors which is proportional to the type of sample, sensor and its sensitivity. In this research, principal component analysis (PCA) and artificial neural networks (ANN) methods were used to analyse the data. The accuracy of these methods are 91.3% and 82.5% respectively.Below shows the excellent graph of obtained results.

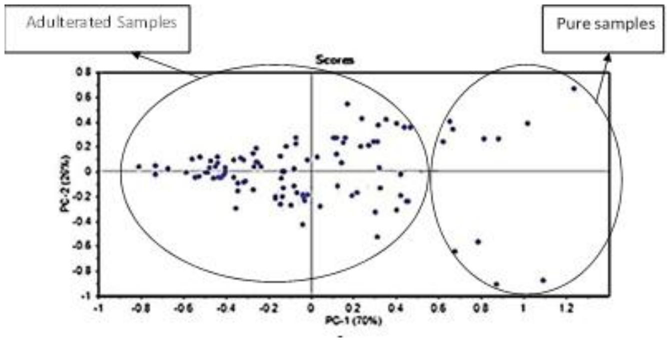


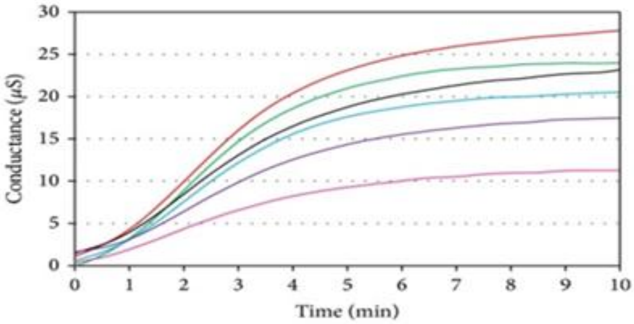
Figure 1: PCA analysis in the diagnosis of cow ghee mixed with cow body fat.

Note: Figure 1 is from "Detection of the adulteration in pure cow ghee by electronic nose method".International Journal of Food Properties ISSN No:-1094-2912 Aug–2018.

Juzong Tan et al. "Application of Electronic nose and Electronic Tongue in food quality related properties determination: A Review" [10]presented that the food quality assessment can be improved by using Electronic nose and Electronic tongue method as compared to traditional detection method. Signals obtained from the E-Nose system when given to the pattern recognition algorithm or pattern classifier like Principle component analysis(PCA), Support Vector Analysis(SVM), Random Forest(RM)enable the recognition of different sample types. However sampling preparation and sampling environment should be precisely controlled as the sensors used in the E-Nose and E-Tongue are easily prone to the temperature, pressure and Humidity.Environment is the big factor affecting the quality of the sensing material. Number of sampling size should not be small. Future E-nose could be developed using nano technology that would almost be the replica of receptors in the human nose.

AmmarZakaria et al. "A Biomimetic Sensor for the classification of honey of different floral origin andthe detection of adulteration"[11] presented that where the traditional laboratory assessment ineffective to detect the adulteration in honey, thecombination of array sensing and multi-modality sensor fusion can detect the adulteration on the same way the human perceive flavors and aromas.

MadihaBougrini et al. "Detection of adulteration in argan oil by using an electronic nose and voltametricelectronic tongue " [12] presented that their attempt is the first of its kind to successfully use the E-nose and E-tongue technology to detect adulteration of argan oil. The heating method is used in a very controlled atmosphere to generate volatiles in the head space of adulterated samples. The E-Nose set up comprises of Tin-Oxide gas sensors TGS 8xx (with xx = 15,22,24,25,and 42). For data analysis PCA, DFA like pattern recognition techniques are used. Excellent graphical representation has been given with various conductance levels w.r.t. adulterated samples.



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100% Com A.O
90%ComA.O+10%S.O
70%ComA.O+30%S.O
50%ComA.O+50%S.O
30%ComA.O+70%S.O
100% Com S.O

Figure 2 :TimeconductanceevolutionoftheTGS842sensorforcomestiblearganoil with sunflower oil.[12]

Naveed Ahmad et al. "Studying heating effect on desi ghee obtained from buffalo milk using fluorescence spectroscopy"[13] presented thecharacterization and thermal deterioration of the desi ghee obtained from buffalo milk using the potential of fluorescence spectroscopy. Heating of desi ghee affects its molecular composition; however the temperature range from 140-170 °C may be defined safe for frying or cooking where it does not lose much of its molecular composition. The rise in the temperature induces prominent spectral variation which confirms the deterioration of valuable vitamins, isomers of conjugate linoleic acid and chlorophyll content.

Harinageswararao et al. "Emission of volatile aldehydes fromheated cooking oils",[14] presented thatwhen cooking oil is heated various volatile organic compounds are emitted. Aldehydes, ketones, alcohols, dienes and acids commonly formed during edible oil heating process. Aldehydes are the major product of this process. Emission of volatiles is constant with time and increase with temperature.

Anna Gliszczynska-Swigl et al. "Electronic nose as a tool for monitoring Authenticity of food- A review" [15] presentedthat quality and authenticity of several food products can be determined by its flavor itself. For these products aroma of the food is enough to discriminate original products from its fraud one. Electronic nose is a rapid and powerful technique which requires no special sample preparation to determine the aroma of the product. The applications of different E-noses and chemometrics for the determination of food authenticity including adulteration and confirmation of origin are discussed here.

AvinashKaushal et al. "Electronic Nose Evolution for food Adulteration – A Review"[16] presented that electronic nose identifies specific component of an odour and analyzes its chemical make up for its identification. Electronic nose consists of mechanism for chemical detection such as array of electronic sensor and a mechanism for pattern recognition such as neural network. This paper illustrates the function of E-nose, its application and investigates the effective use of e-nose in detecting the gases that have some smell developed by volatile organic compounds ethanol, acetone and benzene at different concentration.

AjithRavindran et al. "A study on the use of Spectroscopic techniques to identify food adulteration"[17] presented that Spectroscopy is one of the non-destructive fast and accurate methods of detecting the food adulteration. In spectroscopy the spectrum of component in the material is obtained by unique interaction of components in the material with particular frequency of electromagnetic wave (absorption, transmittance or emission). This type of technique can detect adulteration in powdered as well as liquid foods. NIR and FTIR Spectroscopic techniques are very efficient in predicting the features of liquids food like oil and dairy products. However this is also having some limitations. The instruments are very costly. Low powered handheld instrument that could be easily monitored by common people need to be developed. Development of chemometric technique for stable calibration model is needed here.

Siuli Das et al. "Milk Adulteration and Detection: A Review"[18] focused on various adulterants used in the milk, their health hazards and the electrical means of detecting the milk adulterants.Results of E- Nose that has been used to detect the adulterant in milk is in complete agreement with the ELISA procedure. E-Nose which

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mainly comprises of the sensing element and the pattern recognition technique, can detect the milk volatile compound. Pattern recognition techniques are either Principle component analysis(PCA), Linear Discriminant Analysis (LDA) orArtificial Neural Network (ANN).Sensing element can be made using MOSFETs or SnO2 .

III METHODOLOGY

The whole system consist of sampling unit, detection unit and
Data acquisition system. Block diagram of the system is shown below.

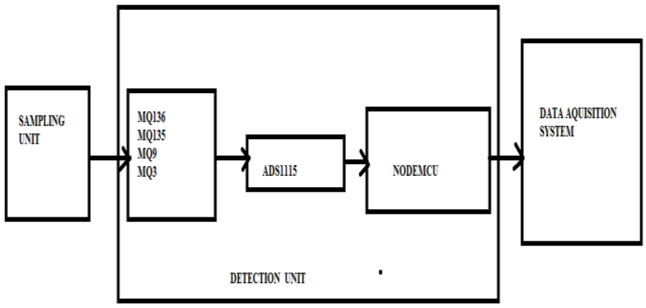

Figure 3: Block diagram of the Electronic Nose system

The adulterated Ghee samples were prepared by mixing Ghee with Dalda/Sunflower oil in the proportion (Ghee: Dalda/Sunflower oil – 100:0 , 80: 20, 60:40, 40: 60, 20: 80, 0:100). These samples are heated at 40–50°C for 10 minutes and the volatiles which are generated are forcefully passed through to the E- Nose via 12 V micro vaccume pump. E-Nose consists of four sensors namely MQ136, MQ135, MQ9, MQ3. Amongst these sensors MQ136 is the most sensitive sensor to the volatiles of the samples. Data analysis is done using a classifier.

IV RESULTS AND DISCUSSION

It is found that the MQ136 sensor is more sensitive to the volatiles from the heated samples of the adulterated Ghee. The SO2 level of the adulterated ghee samples for Dalda is increased with the adulteration, while for the sunflower oil it decreases.

VCONCLUSION

In this way, an Electronic Nose made up of MOSFET or SnO2 can be used for detecting the adulteration in various types of food items. Pattern recognition techniques like Principle Component Analysis (PCA), Linear Discriminant Analysis(LDA), Artificial Neural Network(ANN) can be used to analyze the data. Future food adulteration technology will be the portable one which will use the nano sensors.

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