Detection of Adulterants in Row Milk using Prototype E-Nose

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***Abstract*— Milk can be defined as a whitish liquid containing protein, fats, lactose and various vitamins and minerals produced by the mammary gland of all adult female mammals after childbirth and serves as food for their young ones. The nutritional value of milk is high due to the balanced nutrients in it. The composition varies among animal species and breeds within the same depending on lactation period and diet. Milk secreted when mammals give birth to their young ones is called colostrum's which contain more mineral salts, protein, fat content, calcium and less lactose than normal raw milk.**

Keywords-: E-Nose (electronic nose), Sensor array, VOC's(volatile organic compound),Gas sensors, TGS sensors, heating voltage, circuit voltage.

I. INTRODUCTION

Chemically Milk is a complex fluid which consists of more than hundreds of chemical compounds such as traces of vitamins, enzymes and dissolved gases and also contains dissolved salts, especially in the form of phosphates, nitrates and chlorides of calcium, magnesium, potassium and sodium. The four major components of milk which are dominant in quantitative terms are water, fats, protein, and lactose; while the minor components are minerals, enzymes, vitamins and dissolved gases. It also contains dissolved gases (5% by volume), mainly carbon dioxide (CO_2), nitrogen (N) and oxygen (O_2).

Milk from a healthy cow that is raw milk contains complex mixtures of volatile organic compounds such as acetone, acetaldehyde, 2-pentanone, toluene, limonene, heptanol etc., at various concentrations along with various bacterial pathogens such as bacillus cereus, salmonella; Escherichia coli etc., Most of these microbes are useful in case of curdling or yogurt culturing. But at the same time they are also responsible for rapid spoilage of milk as they ferment lactose with the production of acids and gas and hence they degrade the milk proteins.

Milk and dairy-based ingredients are used as components of many Food products. Their combination consists of unique flavor, desirable texture, and excellent nutritive value. Thus, dairy ingredient provides a consumer-friendly label on packaged foods. As a food ingredient milk provides an excellent nutritional profile in the human diet. Nutrition experts consider milk an exceptionally complete food because it contains significant levels of required nutrients such as protein, fat, carbohydrates, minerals, and several vitamins. Low fat milks are increasingly popular in fat-reduced and fat-free food formulations. Thus worldwide, milk of the cow is by far of more commercial importance than milk of any other mammal. Thus before processing the milk for the manufacturing of food products in dairy industries and as well before using milk in the home or anywhere else it is necessary to ensure the quality of milk.

A. Problem statement

Failure of conventional methods such as chemical methods in some of the milk industries uses the chemicals for testing milk which is time consuming and wastage of milk samples as well as cost of chemicals is more. Due to adulteration in milk there are lot of health issues comes into picture.

B. Motivation

Some the news channels shows that the duplicate milk is came in the market and that is harmful, that is the major motivation to do our project. For the survey we visited KMF (Karnataka Milk Factory, Mysore), they uses the chemical methods for testing and the wastage of milk during testing is about 100 to 200ml per batch.

C. Existing system

There is no electronic equipment's in milk industries; the milk industries uses only the chemical methods to test the milk and the chemical method will not give the accurate results.

II. PROBLEM SOLVING METHODOLOGY

The first step is to identify the milk adulteration, what are all chemicals present in adulterated milk. Identifying the respective E-nose sensors. Collection of various milk samples. Interface sensors and get the data values. Using these values differentiate milk samples.

A. Description

The adulterants in milk can be identified by using Gas sensors, the concentration of chemicals such as ammonia, formalin, hydrogen peroxide etc. output from the gas sensor is given to the ADC circuit and that value is taken for analysis.

B. Flow chart

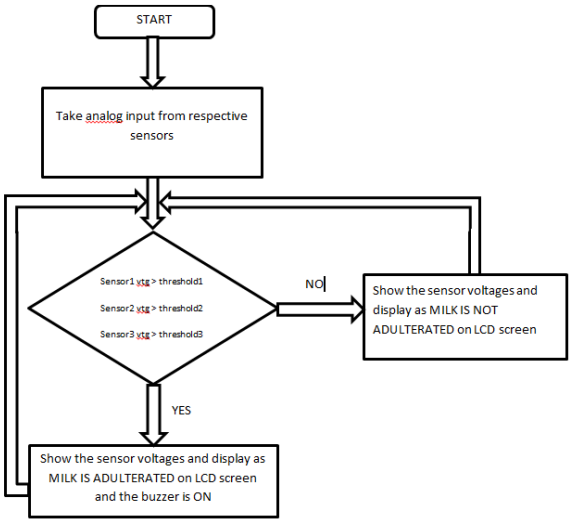

Fig.1. Flow chart

The figure 1 shows that the flow chart of the project. The very first step is to taking the analog inputs from various sensors and that analog voltages are compared with the specified threshold voltages of respective sensors, if any one sensor voltage exceeds the corresponding threshold voltage then it displays "MILK IS ADULTERATED". If all conditions are false then the display will shows "MILK IS NOT ADULTERATED".

C. Block diagram

For the detection of various chemical in row milk, in which it detects milk is adulterated or not, depends on the concentration of chemicals in the row milk.

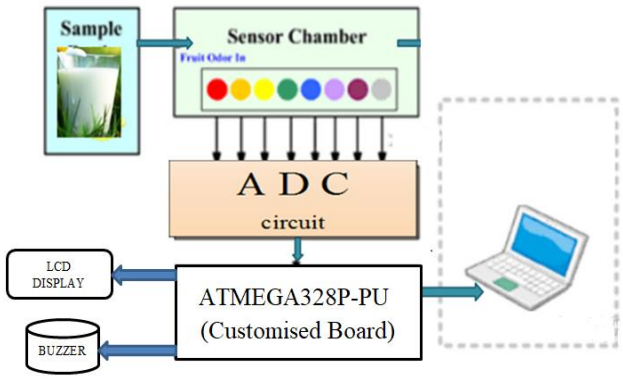

Fig. 2. Block Diagram

The figure 2 shows the block diagram of the project module. it consists of various functional blocks, the milk samples are taken from various sources and they are tested using the sensor by placing the sensors on the specified distance. the voltage coming out from the sensors is normally analog in nature that analog voltage is given to the adc circuit for digital conversion. adc circuit is a on board circuit which converts analog input from sensors is converted into digital values. that digital values are given to the controller board which compares the values got from adc circuit and threshold value which is mentioned in the program if the condition is satisfied then the lcd display will shows that "milk is adulterated" and buzzer will on, if the condition is false the display will shows that "milk is not adulterated" and buzzer will off, here we can monitor the voltage coming from the sensors. The atmega328p-pu is a customized board which is extended type of arduinuno. The atmega328p-pu is an 8-bit controller of having 15mhz operating frequency.

D. Gas sensor array

Gas sensor is a subclass of chemical sensors. Gas sensor measures the concentration of gas in its vicinity. Gas sensor interacts with a gas to measure its concentration. An array of these gas sensors are employed since they are non-specific. These sensors are similar to the mammalian nose as they recognize the patterns of response to vapors and hence also called as olfactory sensors.

A sensor is a device that detects and responds to some kind of input from the environment. The specific input could be light, heat, motion, moisture, pressure or any one of a great number of other environmental phenomena. The output is generally a signal that is converted to human-readable display at the sensor location or transmitted electronically over a network for reading or further processing.

Out of several kinds of sensors, here MOS gas sensors are used. Because gas concentration in the air can be detected by measuring the resistance change of MOS-type gas sensors. The chemical reaction of gases and adsorbed oxygen on the tin dioxide surface varies depending on the reactivity of sensing materials and working temperature of the sensor.

Semiconductor gas sensors (metal oxide sensors) are electrical conductivity sensors. The resistance of their active sensing layer changes due to contact with the gas to be detected. In the ideal case, the gas reacts with the sensor surface in a completely reversible reaction. Due to their chemical composition and properties, metal oxide gas sensors are well-suited for a wide range of applications and for the detection of all reactive gases.

The power consumption of the metal oxide gas sensors varies based on the design of the sensor. The power consumption can be reduced by the thermal decoupling of the sensor from the housing, for example through the use of micro mechanical structures, called micro-hotplates.

A gas sensor is "a chemical sensor is a device that transforms chemical information, ranging from the concentration of a specific sample component to total composition analysis, into an analytically useful signal. The chemical information, mentioned above, may originate from a chemical reaction of the analytic or from a physical property of the system investigated".

Gas sensor is a subclass of chemical sensors. Gas sensor measures the concentration of gas in its vicinity. Gas sensor interacts with a gas to measure its concentration. Each gas has a unique breakdown voltage i.e. the electric field at which it is ionized. Sensor identifies gases by measuring these voltages. The concentration of the gas can be determined by measuring the current discharge in the device.

- The detection system, which consists of a sensor set, is the "reactive" part of the instrument.
- When in contact with volatile compounds, the sensors react, which means they experience a change of electrical properties. Each sensor is sensitive to all volatile molecules but each in their specific way.

- Most systems use sensor-arrays that react to volatile compounds on contact
- The adsorption of volatile compounds on the sensor surface causes a physical change of the sensor.
- A specific response is recorded by the electronic interface transforming the signal into a digital value i.e. the voltage value.

The sensors used in this project are TGS 2602, TGS 813 and TGS 2620. These sensors detect the following gases

- TGS 2602 is used to detect Formalin
- TGS 2620 is used to detect ammonia.
- TGS 813 is used to detect hydrogen peroxide.

These sensors have a heater and sensing element, the sensor is provides two voltages Vh (heater voltage) and Vc (circuit voltage).The heater voltage is applied to the integrated heater in order to maintain the sensing element at a specific temperature which is optimal for sensing. Circuit voltage (Vc) is applied to allow measurement of voltage (Vout) across a load resistor (RL) which is connected in series with the sensor.

E. Components of Gas sensors

Small like nose, gas sensors spontaneously react to the gas present, thus keeping the system update about any alterations that occur in the concentration of molecules at gaseous state.

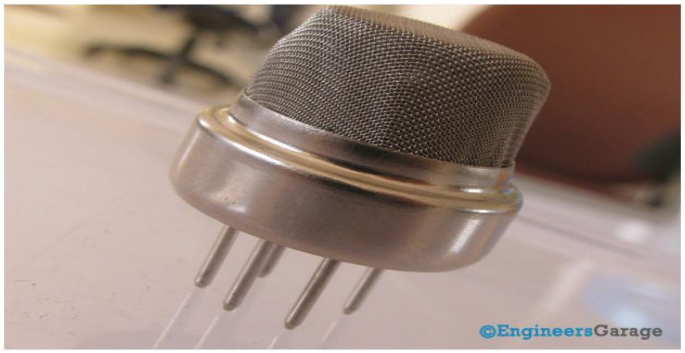

Fig. 3. Gas sensor module

The gas sensor module consists of a steel exoskeleton under which a sensing element is housed. This sensing element is subjected to voltage through connecting leads. This voltage is known as heating voltage through it; the gases coming close to the sensing element get ionized and are adsorbed by the sensing element. This changes the resistance of the sensing element which alters the voltage going out of it.

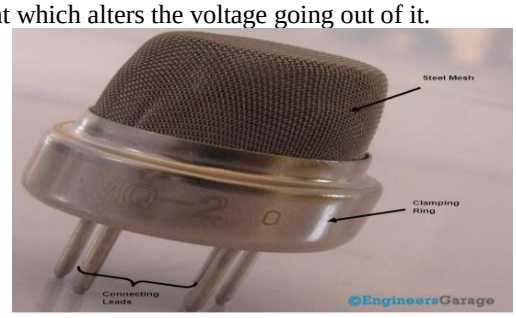

Fig. 4. Externals of a gas sensor

Image shows the externals of a standard gas sensor module: a steel mesh, copper clamping ring and connecting leads. The top part is stainless steel mesh. The steel mesh is made into two layers. The mesh is bound to rest of the body via a copper plated clamping ring.

Fig. 5. Steel mesh of two layers

The connecting leads of the sensor are thick so that sensor can be connected firmly to the circuit and sufficient amount of heat gets conducted to the inside part. They are casted from a copper and have tin plating over them. Four of the six leads (A, B, C, D) are for signal fetching while two (1, 2) are used to provide sufficient heat to the sensing element. The pins are placed on a Bakelite base which is a good insulator and provides firm gripping to the connecting leads of the sensor.

F. Electronic Nose Technology

Electronic Nose is a smart instrument that is designed to detect and discriminate among complex odors using an array of sensors. The array of sensors consists of a number of broadly tuned (non-specific) sensors that are treated with a variety of odor-sensitive biological or chemical materials. An odor stimulus generates a characteristic fingerprint from this array of sensors. Patterns or fingerprints from known odors are used to construct a database and train a pattern recognition system so that unknown odors can Neural Network based Soft Computing Techniques are used to tune near accurate co-relation smell print of multi-sensor array with that of Tea Tasters' scores. The software framework has been designed with adequate flexibility and openness so that tea planters themselves may train the system with their own system of scoring so that the instrument will, then on, reliably predict such smell print scores. Subsequently be classified and/or identified.

- Electronic nose is a device that identifies the specific Components of an odor and analyzes its chemical makeup to identify it.
- An electronic nose consists of mechanism for identification of chemical detection such as an array of electronic sensors and a mechanism for pattern recognition.

An electronic nose is such an array of non-specific chemical sensors, controlled and analyzed electronically, which mimics the action of the mammalian nose by recognizing patterns of response to vapors. The sensors used in the device discussed here are conduct metric chemical sensors which change resistance when the composition of its environment changes. These sensors are not specific to any one vapor; it is in the use of an array of sensors, each of which responds differently, that gases and gas mixtures can be identified by the pattern of response of the array. Electronic Noses have been discussed by several authors, and may be applied to environmental monitoring as well as to quality control in such wide fields as food processing and industrial environmental monitoring. In the device designed and built for crew habitat air monitoring, a baseline of clean air is established, and deviations from that baseline are recorded as changes in

resistance of these sensors. The pattern of distributed response of the sensors is de convoluted, and contaminants identified and quantified by using a set of software analysis routines developed for this purpose. The overall goal of the program at JPL/Caltech has been the development of a miniature sensor which may be used to monitor the breathing air in the International Space Station, and which may be coordinated with the environmental control system to solve air quality problems without crew intervention.

The Electronic Nose uses an array of sensors that function on the principle similar to that of human olfaction. The sensor array generates a pattern based on the type of aroma. The patterns obtained are trained to help interpret and distinguish amongst various odors and odorants as well as to recognize new patterns using advanced mathematical techniques, such as pattern recognition algorithms, principal component analysis, discriminant function analysis, cluster analysis, and artificial neural networks.

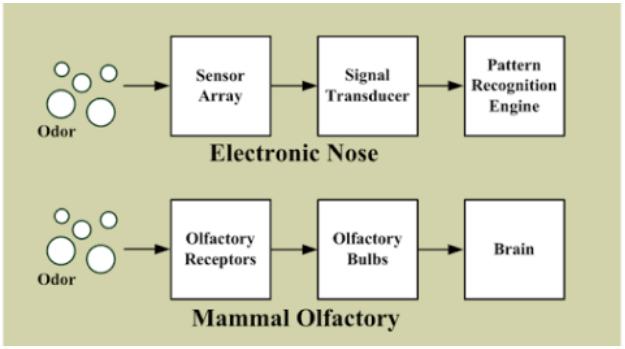

Fig. 6. Comparison of E-Nose with human olfaction

Electronic nose can be compared to the mammal olfactory system as shown in figure above In the mammal olfactory system odor is sensed by the olfactory receptors which are then sent to the olfactory bulbs, these signals are sent to the brain. Brain interprets these signals and recognizes the corresponding odor. In the similar way, in electronic nose odor is subjected to sensor array which is sent to the transducer, it is then recognized by the pattern recognition engine.

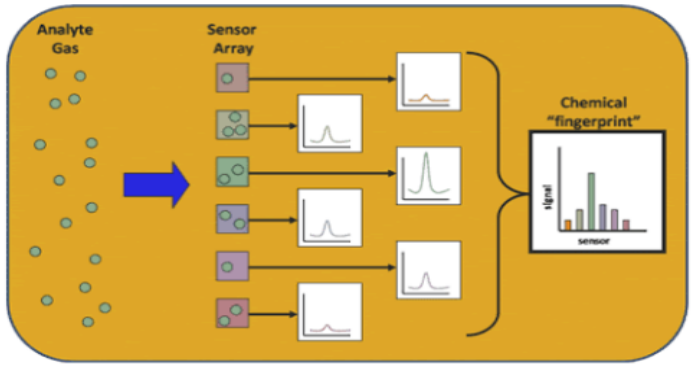

Fig. 7. Sensor Array

A sensor array is a group of sensors, usually deployed in a certain geometry pattern, used for collecting and processing electromagnetic or acoustic signals. The advantage of using a sensor array over using a single sensor lies in the fact that an array adds new dimensions to the observation, helping to estimate more parameters and improve the estimation performance.

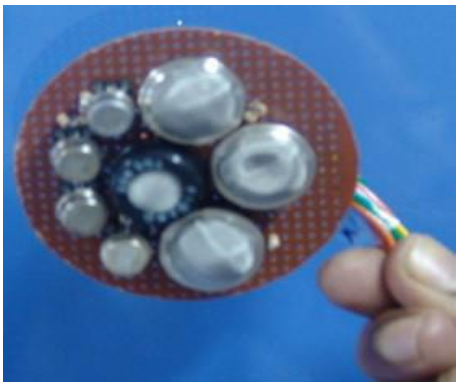

Fig. 8. Sensor Array

The general working mechanism of a sensor is illustrated by the following scheme. In the field of sensors, the correct definition of parameters is of paramount importance because of these parameters:

- Allow the diffusion of more reliable information among researchers or sensor operators.
- Allow a better comprehension of the intrinsic behavior of the sensors help to propose new standards, give fundamental criteria for a sound evaluation of different sensor performances. The output signal is the response of the sensor when the sensitive material undergoes modification.

The sensors in the electronic nose are polymer films which have been loaded with a conductive medium, in this case carbon black. A baseline resistance of each film is established; as the constituents in the air change, the films swell or contract in response to the new composition of the air, and the resistance changes. In the electronic nose, sensing films were deposited on co-fired ceramic substrates which were provided with eight Au-Pd electrode sets.

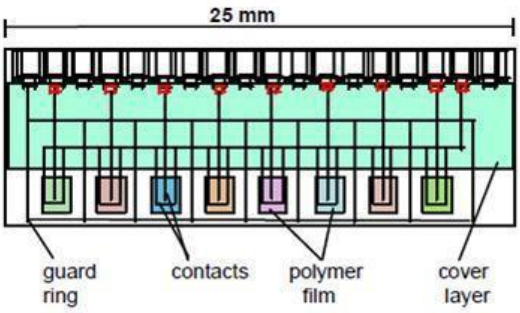

Fig. 9. Sketch of the ceramic substrate chip containing Eight sensors

III. EXPERIMENTAL RESULTS

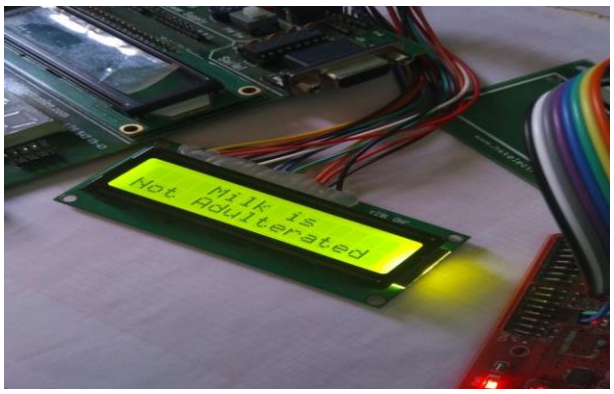

Fig. 10. Display if milk is not adulterated

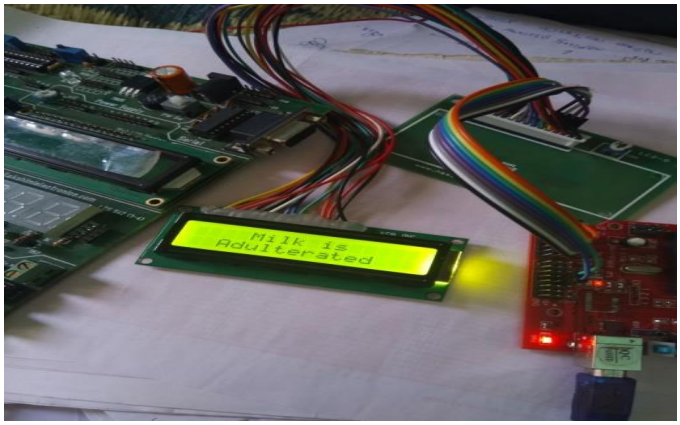

Fig. 11. Display if milk is adulterated

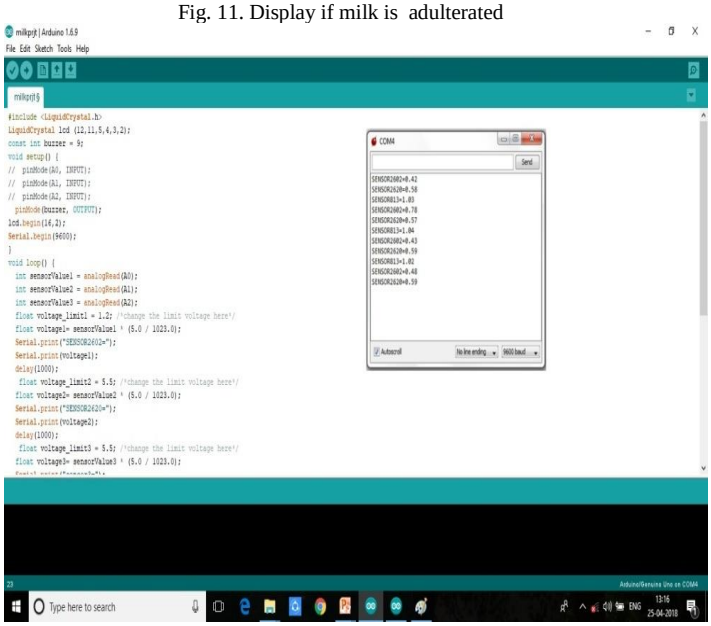

Fig 12**:** serial output (output voltages)

IV. CONCLUSION AND FUTURE WORK

The method of detection of adulterants using gas sensor array depicts:

- We can detect the adulteration in milk.
- Differentiate between the pure and adulterated milk.
- This method can be implemented in the dairy industries to avoid mixing of adulterated milk with other milk.
- Easy to handle, gas sensors are economical.
- Adulterants detection using gas sensors array has minimum procedural steps.
- Prevents the disices coused by milk adulteration.
- Government can take over this project and make a cirtification for this.

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