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# EVALUATION OF FRUIT RIPENESS USING ELECTRONIC NOSE

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**Abstract-**This paper describes about the use of Electronic nose or an artificial nose that mimics the behaviour of human nose.Electronic nose is defined as an instrument which comprises of a sensor for recognizing simple or complex odour. One of the main concerns of the food industry is the systematic determination of fruit ripeness under harvest and post-harvest conditions, because variability in ripeness is identified by consumers as a lack of quality. Most of the traditional methods that have been used to access fruit ripeness are destructive and thus cannot be readily applied. Hence we use ethylene gas sensor to detect the fruit ripeness as ethylene gas is the key component in fruit maturation. A good correlation between sensor signals and some fruit quality indicators was also found. These results prove that E-NOSE can be used as a quality control tool i.e., it has been used for continuous monitoring of fruit freshness during its point of sale and shipment.

***Keywords:*** Fruit Ripeness, Artificial Olfaction, Electronic Nose, Ethylene Gas Sensor.

## 1. INTRODUCTION

The increasing competition in domestic and international fruit markets is generating the need for improved ripeness evaluation techniques so that potential losses to the grower and packer, as well as fast spoilage at the consumer end, can be minimized. A lot of techniques have been carried out in measuring fruit ripeness which does not directly depend on the maturity stages of the fruit[5,6]. They include a list of maturity indices like (starch, firmness, juice sugar and acid content, seed colour, flesh colour, presence of water core, background colour, and internal ethylene concentration (IEC) etc.,

Smells are chemical sense which is used to detect the presence of different chemicals (molecules) in the air medium. There are over 600 different molecular which wafers into our nose while making up the delicious fresh coffee.

The human sense of smell is poor when compared with many animals. Humans can easily detect just parts per billion of toxic gas i.e., hydrogen sulphide, the smell of rotten egg. With certain experience, the human nose can identify the products as fish, cheese, wine, orange and etc., for quality and freshness.

**Firmness**: Fruit firmness measurement is a good way to monitor fruit softening and to predict damage during harvest and post-harvest handling. Fruit firmness can be measured with either an Effigi fruit tester or a Magness-Taylor pressure tester. Both works on the principle that fruit flesh becomes softer as it matures. Many factors, including water core and fruit size can affect firmness readings. The presence of water core will give higher readings that are inaccurate. For the fresh fruit market, measuring firmness during postharvest handling (production and retail sites) are key tools for controlling ripening. This provides useful information to manage marketing, storage and shipment decisions for several commodities.

**Colorimetry**: Colour is the most important external characteristic to assess ripeness and postharvest life, and is a major factor in the consumer's purchase decision. Degree ofripening is usually estimated by colour charts. Colorimeters, on the other hand, express colours in numerical terms along the L*, a* and b* axes (from white to black, green to red and blue to yellow, respectively) within the CIELAB colour sphere which are usually mathematically combined to calculate the colour indexes.

**Determination of fruit acids by titration and calculation of the sugar/acid ratio:**

It is the sugar or acid ratio which contributes towards many fruits their characteristic flavour and it is an indicator of commercial and organoleptic (involving the use of sense organ) ripeness. At the beginning of the ripening process the sugar/acid ratio is low, because of low sugar content and high fruit acid content, this makes the fruit taste sour. During ripening, the fruit acids gets degraded, the sugar content gets increases and the sugar/acid ratio achieves a higher value. Over riped fruits have very low levels of fruit acid and therefore lack characteristic flavour.

Titration is one among the chemical process used in certain amount of constituent substance in a

sample, e.g. acids, by using a standard counter-active reagent, e.g. an alkali (NaOH). Once the acid level in a sample has been determined it can be used to find the ratio of sugar to acid. There are two different methods in specific used for the determination of the titratable acidity of fruits

- Method using a coloured indicator
- Potentiometric method: -using a pH meter, which should be used for very coloured juices.

**Starch levels**: Stage of maturity can also be assessed by performing the starch-iodine test to
Document starch disappearance. Applying an iodine solution along the cut surface of fruit stains the starch a blue black. The iodine solution can be made by dissolving 10 grams of iodine crystals and 25 grams of potassium iodide in 1 litre of water. The pattern of starch disappearance is specific for each variety.

b) **Ethylene production:**

As fruits ripen, the concentration of volatile compound called ethyleneincreases. Its presence activates the ripening process and the ripening process produces more ethylene in climacteric fruit (such as pears, apples, and peaches). The discharge of these volatiles is that one the consumers smell when eating ripe fruit, contributing to their enjoyment of the fruit. This aroma profile of a fruit can be measured non-destructively by placing the fruit in a sealed container, such as a glass jar or a plastic bag and the concentration of ethylene can be sensed with the help of an ethylene gas sensor. Figure 1 shows the ethylene structure.

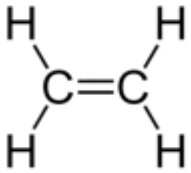



**Fig 1: Ethylene (C2H4)**

An aroma compound, also known as odorant, aroma, fragrance or flavour is a chemical compound that has a smell or odour. Generally, an odour is composed of molecules, in which each molecule has a specific size and shape. Each of these molecules has a correspondingly sized and shaped receptor in the human nose. When a particular receptor receives a molecule, it send the signal to the brain and then the brain identifies the smell associated with that particular molecule. Electronic noses based on the biological model, works in a similar manner,

Substituting sensors for the receptors, and transmitting the signal to a program for processing, rather than to the brain.

## 2. ELECTRONIC NOSE DESIGN:

We designed an electronic nose to measure the fruit ripeness based on ethylene concentration. In this design we used an ethylene gas sensor to detect the ethylene concentration inside the glass chamber (where fruit was placed for a long period of time). An electronic nose system consists of three unit's namely sampling system, sensing system and processing system which are described below in figure 2.

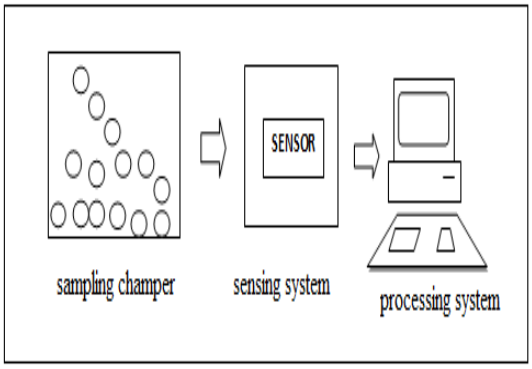



**Fig 2: Design Structure**

## 3. IMPLEMENTATION:

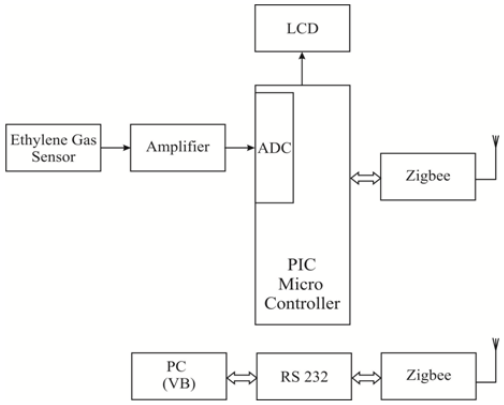
The major component of an e-nose system is the ethylene gas sensor which senses the presence of ethylene (C2H4) concentration in the fruit samples. The sensor output is then given to ADC in the microcontroller unit, used for converting the analog signals into digital, to linearize the values.

The ethylene concentration thus obtained in terms of parts per million (ppm) is displayed in the LCD display. Also classification and coding mechanisms are coded into MCU so that this setup serves the purpose of classifying the maturity stages of the fruit based on the ethylene concentration. The various modules of the system are described below in figure 3.

**Transmitter:** This module consists of the power supply unit, sensing element and the PIC16F877A Microcontroller.

**Power supply:** The ac voltage, in general 220V rms, is connected to a transformer, which steps that the ac voltage down to the level of the desired dc output. A diode rectifier then provides a full-wave rectified voltage that is initially filtered by a simple capacitor filter to produce a dc voltage. Here the resulting dc voltage usually has some ripple or ac

voltage variation. A regulator circuit will remove the ripples and also maintains the same dc value even if the input dc voltage varies. This voltage regulation is usually obtained using one of the popular voltage regulator IC units. The constant DC voltage obtained from the power supply enables the sensor.




a)

**Fig 3.Block diagram of E-nose using PIC16F877A**

b)

### 3.1. ETHYLENE GAS SENSOR:

Ethylene gas sensor is capable of sensing that is released from the fruits. The fabrication and design process are simple, the sensor senses the ethylene and produces a voltage output. The produced analog output is proportional to the concentration of the ethylene. With the help of simple circuitry the obtained voltage output from the sensor is converted to a digital value. This sensor senses ethylene in the range of 20-2000 ppm. It is used for continuous monitoring and they have longer life.

**Features of ethylene gas sensor:**

- Continuous monitoring
- Long life sensor
- Easy/calibration
- Reverse polarity protected
- Overload protected
- 2-10V analog signal output


**Fig.4.Ethylene Gas Sensor**

#### 3.1.1 .Working Principle of Gas Sensor:

Using the voltage regulator IC 7805, a constant 5V supply is given to the sensor. The constant DC voltage obtained from the power supply enables the sensor. It consists of two electrodes and when the ethylene ions come in contact with these electrodes, a current flow takes place between them. The amount of current is proportional to the number of ethylene ions. These currents give rise to a voltage and hence this sensor allows the detection of ethylene gas from the fruit samples.

**Sensing element:** The sensing element consists of en ethylene gas sensor which senses the presence of ethylene gas present in the air. The sensor provides varying voltage proportional to the concentration of ethylene gas present. This devised sensor senses ethylene in the range of PPM. The voltage signal obtained from the sensor is given to Analog-to-Digital convertor in PIC controller. This type of sensor can be used for continuous monitoring and also they have longer life.

**PIC microcontroller:** PIC is a family of Harvard architecture microcontrollers made by Microchip Technology. A MCU is used for converting the analog values from sensor into digital value using ADC peripheral inside the microcontroller. The PIC16F77A is programmed using software such that the classification of the input samples can be displayed in the LCD based on the threshold values which can be varied depending upon the ethylene concentration of the input samples. The ethylene concentration thus displayed in the LCD is transferred to the receiver module through ZIGBEE protocol.

**Receiver:** The information received by zigbee is sent to the PC through RS-232. The information containing the statistical value of the ethylene concentrations in terms of ppm are displayed in the PC through VISUAL BASIC software.

## 4. RESULTS AND DISCUSSION

### 4.1. Different Levels of Ethylene Concentration at various Maturity Stages:

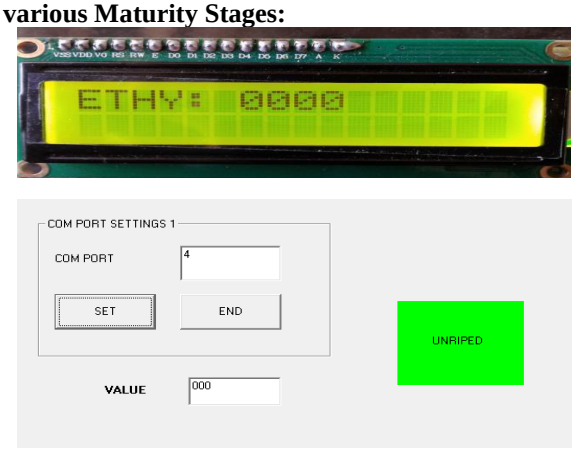



**Fig.5. Simulation Result of Unriped fruit**

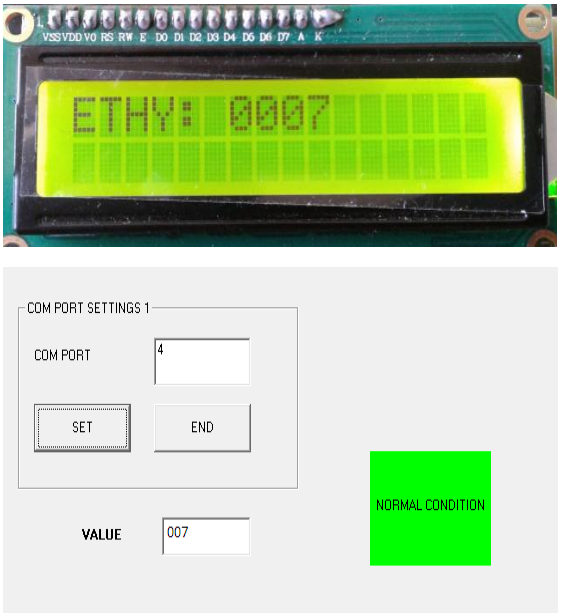



**Fig .6. Simulation Result of Riped Fruit**

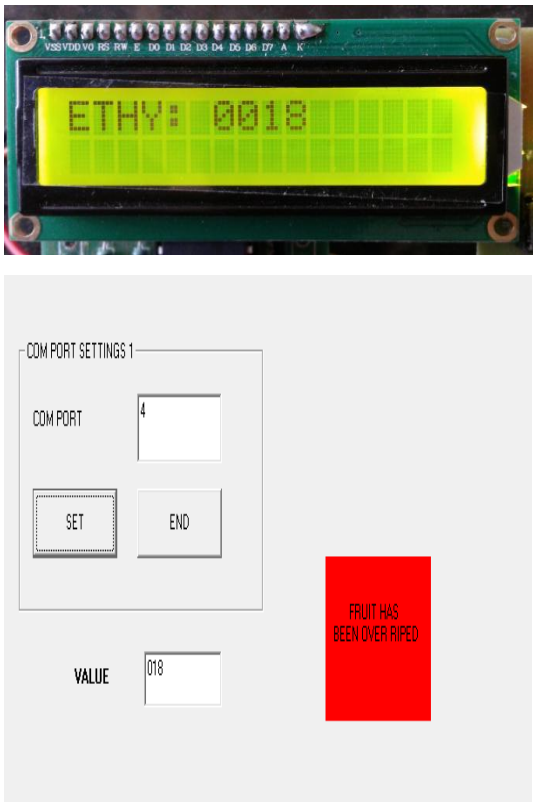



**Fig.7. Simulation Result of Over-riped fruit**

**Figure 5, 6, 7 shows the simulation results of the proposed method.**

**Table 1: Results Obtained For Mango:**

| | Ethylene concentration (PPM) | | |
|---|---|---|---|
| Observed days | Unripe | Normal condition | Over-ripe |
| Day 1 | 0 | 5 | 13 |
| Day 2 | 0 | 8 | 16 |
| Day 3 | 1 | 12 | 18 |
| Day 4 | 3 | 16 | 21 |

The proposed model provides an effective solution to measure the ethylene content without causing any destruction to the sample chosen.In this work, an application-specific sensor system used to measure fruit ripeness has been implemented and tested. Studies with apples and mango, where electronic nose measurements have been correlated with well-established fruit-quality techniques, have shown that some quality parameters can be predicted reasonably well using electronic nose signals without destroying the fruit. It's enough to train the sensor once for different fruits, it will produce accurate concentration of ethylene in the range of ppm and also there is no need of manual labour. Using ethylene gas sensor along with microcontroller the ethylene concentration of fruits are effectively determined than the previously available techniques and accordingly the ripening stages which are classified as over-ripe, Ripe and un-ripe. The proposed non- destructive system using Ethylene gas sensor can be used for any kind of fruits since all the fruits emit ethylene while they ripe.

## 5. CONCLUSION

The concentration of ethylene varies at the different stages of fruit ripening and thus the fruits are classified according to their maturity stages. The compactness of this hardware is very less since it consists of a sensor integrated with PIC and LCD display. Since the output is interfaced to PC using ZIGBEE protocol there will be less traffic during transmission. In order to guarantee a certain standard of raw materials as well as final products, quality control in different industries becomes increasingly important. Hence the proposed E-nose system can be widely used in quality control of food and packaging materials.Some of the other areas where this Electronic Nose system can be extended to, have been listedbelow

- Quality control laboratories
- In agriculture during harvesting
- Food production industries

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