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Quality Detection of Beverage Using Sensor

Safreena Kabeer[1], Pavithra Veeramani[2], Sivagami Lakshmanan[3*], S. Siva Nandhini[4], R. Vishnu Varthini[5], Yazhini Ashok[6]

[1]*Assistant Professor, Department of Food Processing and Preservation Technology, Avinashilingam Institute for Home Science & Higher Education for Women, Coimbatore, India*

[2,3,4,5,6]*Student, Department of Food Processing and Preservation Technology, Avinashilingam Institute for Home Science & Higher Education for Women, Coimbatore, India*

***Abstract*: The analysis of different kinds of beverages and food stuffs, containing various inorganic and organic substances, assessment of food and beverage quality and recognition of adulteration are urgent practical tasks. [11] We are fabricating a device which enable the detection of all the quality aspects in beverage. Unlike other equipment, this sensor combines all the features in a single detector which is user friendly. The device combines some of the major quality attributes such as pH, moisture level, water quality, chemical and microbiological contamination. It is also proved that this device is user friendly since it comprises all the sensors under a single device. By comparing the values which we derived using this device with the standard values of the tested beverage samples, the values were almost the same. The adulteration of alcoholic beverage may not only be conducted to increase the alcoholic strength by using cheaper source of starch besides grape or fruit. As per the definition by WHO "illegally manufactures spirit drinks are adulterated counterfeit consumption can cause methanol poisoning".**

***Keywords*: Color sensor, ph sensor, quality detection, standard values.**

1. Introduction

Beverage is any liquid consumed by humans for quenching thrust or merely, for pleasure [1]. The analysis of different kinds of beverages and food stuffs, containing various inorganic and organic substances, assessment of food and beverage quality and recognition of adulteration are urgent practical tasks. [11] Even though beverage industries in India have attaining high limits, still there are few issues regarding the quality accepts. The issue of foodborne related illnesses due to additives and contaminants poses a significant challenge to food processing industries. The efficient, economical, and rapid analysis of food additives and contaminants is therefore necessary in order to minimize the risk of public health issues. [9] A very challenging problem in food processing is quality and safety control of food products, in such away much time and effort is spent on methods for this goal accordingly. [10]

Almost every industry has to deal with gas hazards of one kind or another, and the food and beverage industry is no exception. However, throughout the industry, there is a general lack of awareness when it comes to carbon dioxide (CO2) and the issues it can pose for not just workers, but also customers. Thanks to its many uses, carbon dioxide is the most common gas in the food and beverage industry. It's used to add carbonation to soft drinks, keep food items cold during transportation in the form of dry ice, and is released by leavening agents like yeast. Carbon dioxide might seem harmless at first glance. After all, we exhale it with every breath, and plants need it for survival. The presence of carbon dioxide itself is not necessarily a problem, but its volume in a given environment can rise to dangerous levels.

The time dilation of the food products affects its quality. This is due to the results of chemical reactions taking place as time passes. Keeping a check on the food quality before consumption plays a vital role. The industrial sensors are expensive and cannot be used outside of laboratory environment. And other handheld sensors can detect only a specific type of evaluation. This brings the need to combining multiple sensors to a single device also making it transportable easily. During a trek or camping the evaluation of water quality from a stream or pond is vital for survival.

Consumers are gaining awareness regarding the quality aspects in beverage [4]. Hence we offer a new solution to this issue. We are fabricating a device which enable the detection of all the quality aspects in beverage. Unlike other equipment, this sensor combines all the features in a single detector which is user friendly. The device combines some of the major quality attributes such as pH, moisture level, water quality, chemical and microbiological contamination.

2. Sensor Array and Measurement Procedure

The general principle of integrating multiple sensor technique is that the volatile compounds in the headspace of the sample are introduced into the detection system. Then, for each sample analysed, the detector generates a set of signals that contains information about volatile composition of the sample. [12] Measurements with sensor array were made in different sample of cold beverages, Fruit vinegar, Orange Juice, Beer, Coffee, Milk & Distilled water. Sensor array used for measurement in the samples comprised of five sensors pH sensor, Gas sensor, Turbidity sensor, moisture sensor and

*Corresponding author: sivalakshan14@gmail.com

colour sensor.

A. *pH Sensor*

A pH sensor helps to measure the acidity or alkalinity of the water with a value between 0-14. When the pH value dips below seven, the water starts to become more acidic. Any number above seven equates to more alkaline. Each type of pH sensor works differently to measure the quality of water. Measuring the pH can also provide indications of pipe corrosion, solids accumulation, and other harmful by products of an industrial process.

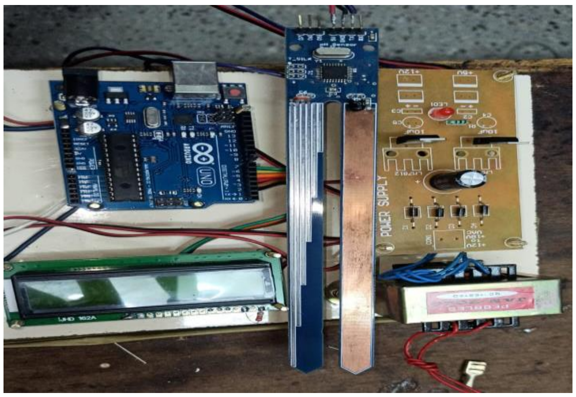

Fig. 1. pH sensor

B. *Gas Sensor*

Gas sensor e-noses operate on the basis of physical and/or chemical interactions of the volatile compounds with an array of solid-state gas sensors, each of which has a partial specificity. [12] Based on the concentration of the gas the sensor produces a corresponding potential difference by changing the resistance of the material inside the sensor, which can be measured as output voltage. Based on this voltage value the type and concentration of the gas can be estimated.

Fig. 2. Gas Sensor

C. *Turbidity Sensor*

The Arduino turbidity sensor detects water quality by measuring the levels of turbidity, or the opaqueness. This sensor has been modified to detect microbial contamination if any, present in the liquids and beverages. It uses light to detect suspended particles in water by measuring the light transmittance and scattering rate, which changes with the amount of total suspended solids (TSS) in water. As the TTS increases, the liquid turbidity level increases, this liquid sensor provides analog and digital signal output modes. The threshold is adjustable when in digital signal mode.

Fig. 3. Turbidity Sensor

D. *Moisture Sensor*

Moisture sensors consist of two conducting plates which function as a probe and acting as a variable resistor together. When the sensor is inserted into the water, the resistance will decrease and get better conductivity between plates. This resistance is inversely proportional to the moisture. The more water in the beverage means better conductivity and will result in a lower resistance. The less water in the beverage means poor conductivity and will result in a higher resistance. The sensor produces an output voltage according to the resistance, which by measuring we can determine the moisture level.

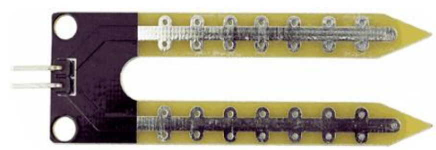

Fig. 4. Moisture Sensor

E. *Colour Sensor*

These sensors are the photoelectric devices that can emit light and detect the colour of reflected light from an object. These sensors can detect the intensity of light reflected from an object and differentiates the primary colours like red, blue, and green. Colours sensors can illuminate the object with broad wavelength, light ratio, and determine the light intensity of primary colours. The ratio of intensity light determines the amount of light reflected and absorbed by the specimen.

Fig. 5. Colour Sensor

3. Methodology

A. *pH sensor interface*

The construction of the pH sensor is integrated using Arduino Uno board with pH sensor interface circuit, pH sensor, variable resistor, BNC connector and Voltmeter. The build is tested on the sample and the comparison of values with pH-voltage relations table is studied.

For interfacing of pH sensor with Arduino, the red wire of variable resistor is connected to Arduino fivefold, Black wire with Arduino ground and blue wire with Arduino end pin at zero. For validating the sensor connectivity, the known liquids have been chosen to seek values that are already known to check its accuracy.

The whole circuit is connected to a LED and a Voltmeter (in V). As the samples are being tested using pH sensor, the voltage readings change for each sample (in mV). These readings are noted for deriving the pH values.

pH numbers also correspond to voltage measurements. The full range of pH scale goes from a low acidic pH 0 = +400 mV to a high alkaline pH 14 = -400 mV level. [5] The collected voltage readings (in mV) can be used to derive the pH values in comparison with this pH-voltage relation table.

- Measuring Range: 0 to 14.00 pH
- Sensitivity: 0.002 pH
- Stability: 0.02 pH per 24 hours, non-cumulative
- Temperature range: (-5) to (+95) ˚C

Table 1
pH value vs. millivolts

millivolts	pH value	millivolts	pH value
+1342.86 mV	1 pH	-57.14 mV	8 pH
+285.71 mV	2 pH	-114.29 mV	9 pH
+228.57 mV	3 pH	-171.43 mV	10pH
+171.43 mV	4 pH	-228.57 mV	11 pH
+114.29 mV	5 pH	-285.71 mV	12 pH
+57.14 mV	6 pH	-342.86 mV	13 pH
0 mV	7 pH	-400 mV	14 pH

B. *Construction of Gas Sensor*

Gas sensor comprises of SnO_2 Gas sensing layer, Ni-chrome Heater coil, Pt Electrode line, Al_2O_3 Tubular ceramic and AU Electrode.

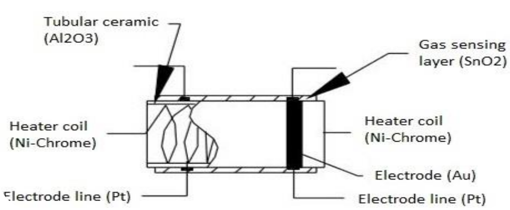

Fig. 6. Gas sensor composition

The ability of a Gas sensor to detect gases depends on the chemiresister to conduct current. The most commonly used chemiresistor is Tin Dioxide (SnO_2). Normally the beverage will contain more oxygen than combustible gases. The oxygen particles attract the free electrons present in SnO_2 which pushes them to the surface of the SnO_2. As there are no free electrons available output current will be zero. When the sensor is placed in gases environment, this reducing gas (orange colour) reacts with the adsorbed oxygen particles and breaks the chemical bond between oxygen and free electrons thus releasing the free electrons. As the free electrons are back to its initial position, they can now conduct current.

- Carbon Dioxide (CO_2): 10,000 ppm - 61-0191RK-02 (Part no.)
- Carbon Dioxide (CO_2): 0 to 5.00%volume - 61-0191RK-03 (Part no.)
- Carbon Dioxide (CO_2): 0 to 50.0% volume - 61-0191RK-05 (Part no.)
- Carbon Dioxide (CO_2): 0 to 50.0% volume - 61-0191RK-10 (Part no.)

C. *Working of turbidity sensor*

The device measures scattered light at 90°. The light transmitted from the source is directed in equal strength to the reference detector and into the medium. Light is scattered from the particles and the portion which is scattered at a 90° angle is received by the detector. The meter now compares the light from the reference detector and scattered light receiver and calculates the turbidity value. The measurement unit for the turbidity measured at a 90° angle varies depending on country in. The advantage of the using NIR as light source is that this sensor is not affected by colour of the medium measured.

- Operating Voltage: 5V DC
- Operating Current: 40mA (MAX)
- Output Method:
  - Analog output: 0-4.5V
  - Digital Output: High/Low level signal.

D. *Construction of Moisture Sensor*

Moisture sensor comprises of AO (Analog Output), DO (Digital Output), VCC & GND (Ground connection). Moisture sensor has two conducting plates. First plate is connected to the +5Volt supply through series resistance of 10K ohm and second plate is connected directly to the ground. It simply acts as a voltage divider bias network, and output is taken directly from the first terminal of the sensor pin, which is shown in figure above. The output will change in the range of 0 – 5 Volt, in proportion with change in content of water in the soil. Ideally, when there is zero moisture in soil, the sensor acts as open circuit i.e. infinite resistance. For this condition, we get 5V at the output.

- Operating Voltage: 3.3V to 5V DC
- Operating Current: 15mA
- PCB Size: 3.2cm x 1.4cm
- LM393 based design.

E. *Working of Colour Sensor*

These sensors detect the colour of an object when subjected to, light rejecting the unwanted UV light and infrared light. When white light is illuminated on the target, the sensor is activated with 3 filters, which have 3 different wavelengths and determines the colour of the target with respect to the RGB scale. We use this technique to identify the presence of any colour additives and caffeine in beverages. When this sensor emits and absorbs the light from the beverage, it determines the intensity of the colour in the sample by which we can know about the ratio of colour additives present in it. By this way, we can also detect the presence/ absence of caffeine in beverages in common.

- Input voltage: (2.7V to 5.5V)
- Interface: Digital TTL

- Working temperature: -40oC to 85oC
- Size: 28.4x28.4mm (1.12x1.12")

4. Results and Discussion

The pH values for different beverage samples have been calculated by using the collected voltage readings (in mV). We were able to observe the evaluated pH values are within the prescribed threshold for each category of beverage. From this we observe tight quality controls measures have been put in place by the manufacturers as the derived pH values are within standards accepted globally. The water sample used for testing has been treated to be neutral and the same has been observed by the pH value reading of 7.

The pH values for the beverage samples are given below:

Table 2
pH value results

BEVERAGE SAMPLES	STANDARD pH VALUES	DERIVED pH VALUES
Cola beverages	2 - 5	2.8
Fruit vinegar	3 - 3.5	3.2
Orange juice	3.9 - 4	3.7
Beer	4 - 5	4.4
Coffee	4.85 – 5.10	5
Milk	6.5 – 6.7	6.6
Distilled water	5 - 7	7

The carbonation values for different carbonated beverages have been derived by using gas sensor.

We observe the CO2 content on the different samples tested. On Coco Cola the content differed by 0.01mol/0.355 L since the CO2 content is influenced and varies to different manufactures and container. The sample we tested was contained in a tin can. Where are the CO2 content observed in Mountain Dew, Sprite were well within the standard range. The CO2 content is 7up was less by 50% due to the time duration post manufacturing.

The carbonation values for the beverage samples are given below:

Table 3
Gas sensor results

BEVERAGE SAMPLES	STANDARD VALUES	DERIVED VALUES
Coco Cola	0.05 mol/0.355 L	0.04mol/0.355 L
Mountain Dew	0.05mol/0.065 L	0.05mol/0.065 L
Sprite	0.10mol/0.422 L	0.07mol/0.422 L
7Up	0.04mol/0.327 L	0.02mol/0.327 L

The contamination values for different samples have been derived by using turbidity sensor. The sensor detects the light refracted due to the solids contained in the sample. As the quantum of solid particles increase in water the amount of transmitted light decreases. The unit of measurement is NTU (Nephelometric Turbidity unit). The values are given below:

Table 4
Turbidity sensor results

SAMPLES	STANDARD VALUES		DERIVED VALUES	
	E. Coli	Enterococci	E. Coli	Enterococci
Fresh water	(126 cfu/100mL)	61 – 151 cfu/100 mL	116 cfu/100mL	125 cfu/100mL

The moisture values for different beverage samples have been derived by using moisture sensor. The dielectric permittivity of the medium tested using the moisture sensor is observed when voltage proportional to the dielectric permittivity is created. This voltage created helps us in analysing the water content on the medium tested. Based on the derived results we cola is made up of 92.55% water, whereas the mango squash contains only 74.6% of water and 25.6% are of non-water components. We observed smoothies contains 84% of water where as standard value of water content on smoothies is 88%, the difference of 4% could be due to the solidification of the smoothie proportionate to the time post manufacturing.

The values for the beverage samples are given below:

Table 5
Moisture sensor results

BEVERAGE SAMPLES	STANDARD VALUES	DERIVED VALUES
Coco cola	94.53%	92.55%
Mango Squash	73.0 - 86.7%	74.6%
Smoothies	88.12%	84.01%

The amount of colour additives present in different beverage samples has been detected. The colour sensor records the intensity of the reflection (brightness) when a white light is shined on the sample. Based on the derived values form the sample tested we were able to observe colour degradation on the Fizz Jeera due to passing of time duration. As the time passes post manufacturing the chemical changes on the sample results in changing of colour. This is well observed on Fizz Jeera as Jeera changes the liquid's colour faster in comparison to the other sample. On the other samples we observed colour range near to the standard values. This helps us understand the usage of colour additives on samples.

Those values are given below:

Table 6
Colour sensor results

BEVERAGE SAMPLES	STANDARD VALUES	DERIVED VALUES
Fanta (Orange)	17	14.6
Fizz Jeera	8	5.3
Appy fizz	12	10.1
Thumbs Up	7	6

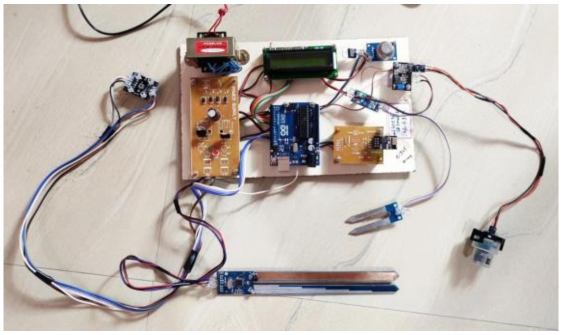

Fig. 7. Complete setup integrating five sensors

5. Conclusion

Thus, we conclude that using this device we were able to evaluate the values for those selected quality parameters of some beverage samples. It is also proved that this device is user friendly since it comprises all the sensors under a single device. By comparing the values which we derived using this device with the standard values of the tested beverage samples, the values were almost the same. Hence, this device will show accurate values for all kinds of beverages. Indian Government has issued a certain set of standard values for all the quality parameters present in beverages and every beverage industries ought to follow these rules and regulations in order to meet the market demands also. So, all the Food and Beverage Industries in India manufactures its products in accordance to the prescribed values.

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