Detection of Food Adulteration using Sensors and Microcontrollers

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The Problem

1. Food Adulteration is widespread in India
2. Formaldehyde, a carcinogen - used to preserve fish in Asia
3. Generally used to preserve dead bodies.
4. Widely used to improve shelf life
5. Has been a hot topic in Goa over the years.
6. No concrete solution

The Urgency

HINDU

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Mr. Tyagi.
TO TAKE CALL ▸ PAGE 10

Fish samples in Chennai test positive for formalin

Minister promises action against those using carcinogen

DEEPA H. RAMAKRISHNAN
CHENNAI

As many as 11 out of 30 samples of fish species purchased from Chinthadripet and Kasimedu, the two major fish markets in Chennai, on two different days, have tested positive for formalin, a cancer-inducing chemical used illegally to preserve fish.

The fish were tested by scientists of the Tamil Nadu Dr. J. Jayalalithaa Fisheries University exclusively for *The Hindu*.

Risky business What the tests on 30 samples revealed

11 samples of fish tested **positive** for **formalin**

6 samples had **mild levels** of formalin (about 5 ppm)
Affected varieties: Hammer head shark, Pacu, Cat fish, Pangasius, Cuttle fish, Octopus

5 samples had **high levels** of formalin (about 20 ppm)
Affected varieties: Big and small lizard fish, big and small Carangid fish

ppm: parts per million

Formalin causes irritation in the eyes, throat, skin and stomach. Long-term exposure could harm kidneys, liver and even cause cancer

Detection kit

A low-cost formalin detection kit developed by researchers of the State-run university was used to test the samples purchased by *The Hindu* for ascertaining if they contained the carcinogen that is used widely as a preservative and disinfectant. The tests were conducted on July 4 and July 8, the days when the fish were purchased.

Only one of 13 samples of fish purchased last Wednesday from the Chinthadripet, Velachery and Neelankarai markets tested positive at the university's referral laboratory in Madhavaram.

However on Sunday as many as 10 of the 17 fish samples purchased from Chinthadripet and Kasimedu markets tested positive for the carcinogen, causing alarm.

Formalin causes irritation in the eyes, throat, skin and stomach. In the long run continued exposure causes harm to the kidneys, liver and can even cause cancers. This is the first time samples of fish in Tamil Nadu have tested positive for formalin.

EXCLUSIVE

Food Safety and Standards Authority of India (FSSAI) officials have been undertaking tests at fish markets and harbours across the State to test for formalin following a scare in neighbouring Kerala that fish sourced from here were chemically contaminated.

Fisheries Minister D. Jayakumar said use of formalin as a preservative cannot be allowed at any cost. He said tests had been conducted in Thoothukudi and other places based on information received by the department but none of those samples had any formalin.

"Since *The Hindu* has brought the [Chennai] test results to our notice, we will lift samples [from fish markets] and conduct tests. We will not hesitate to take strict action against those indulging in such acts," Mr. Jayakumar said.

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A SHOT OF FORMALIN AND A SEA OF TROUBLE ▸ PAGE 2

Figure: The Hindu, 17 October 2018

The Urgency

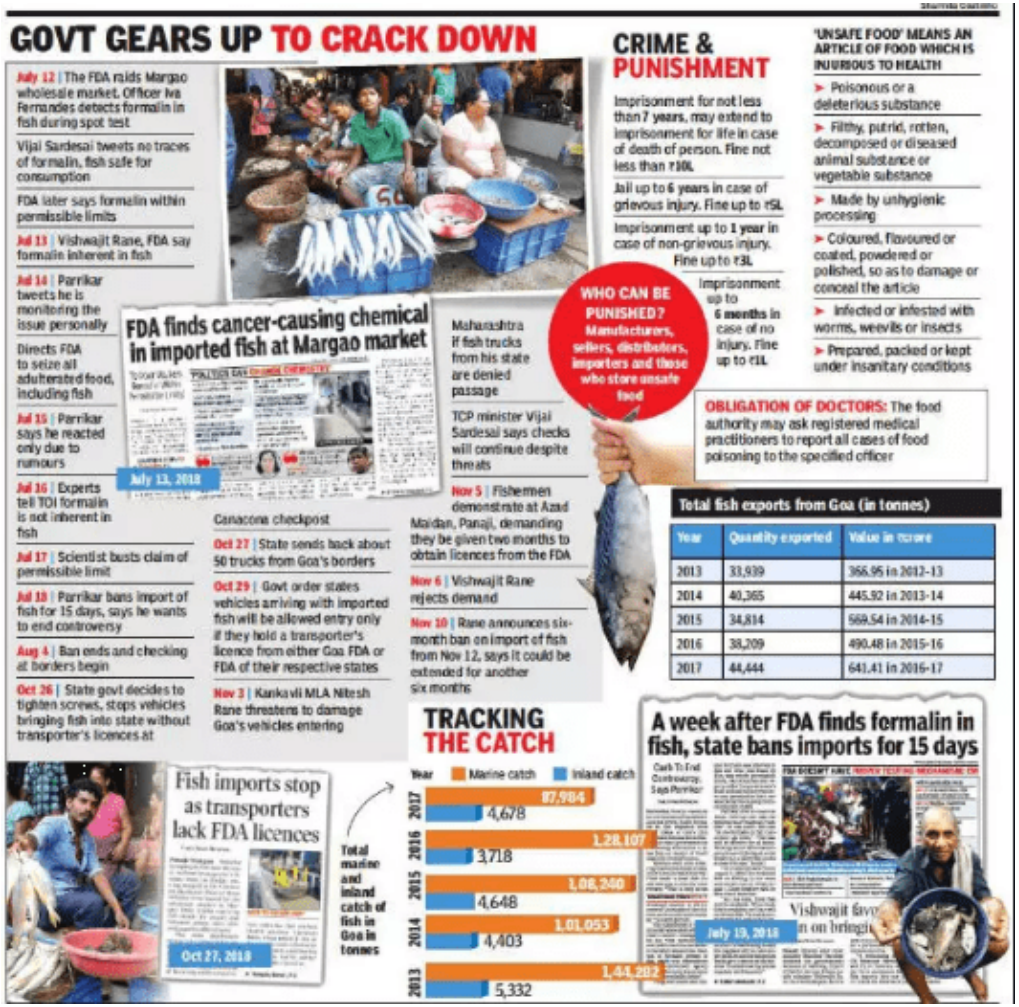

Figure: Times of India, 5 December 2017

Motivation

1. To design a reliable food adulteration detection device to detect presence of Formaldehyde, Benzene, Toluene adulteration.
2. To have both quantitative and qualitative analysis of the adulterant
3. To have fast response time and accuracy during detection

Methods

1. Analytical Methods
   - Gas Chromatography-Mass Spectrometry [1]
   - High Performance Liquid Chomatography [2]
2. Electrochemistry and Fluorometric Methods
3. Colorimetric and Spectrophotometric Methods [3]

Alternatives

Figure: Formaldehyde Meter Z-300

Source: BC Group International, Inc.

Figure: FoodSniffer

Source: ARS Lab US, Inc.

Principle

1. Formaldehyde, a volatile organic compound
2. Conductivity increases with formaldehyde content in surroundings.
3. Conductivity increase is gauged by a MOS sensor
4. Conductivity is mapped to concentration levels.

[4]

Design

- Food sniffed using VOC Gas Sensor(E-Nose)
- Values fed and decoded via microcontroller
- Detection output is displayed onto an LCD screen

[4]

Block Diagram

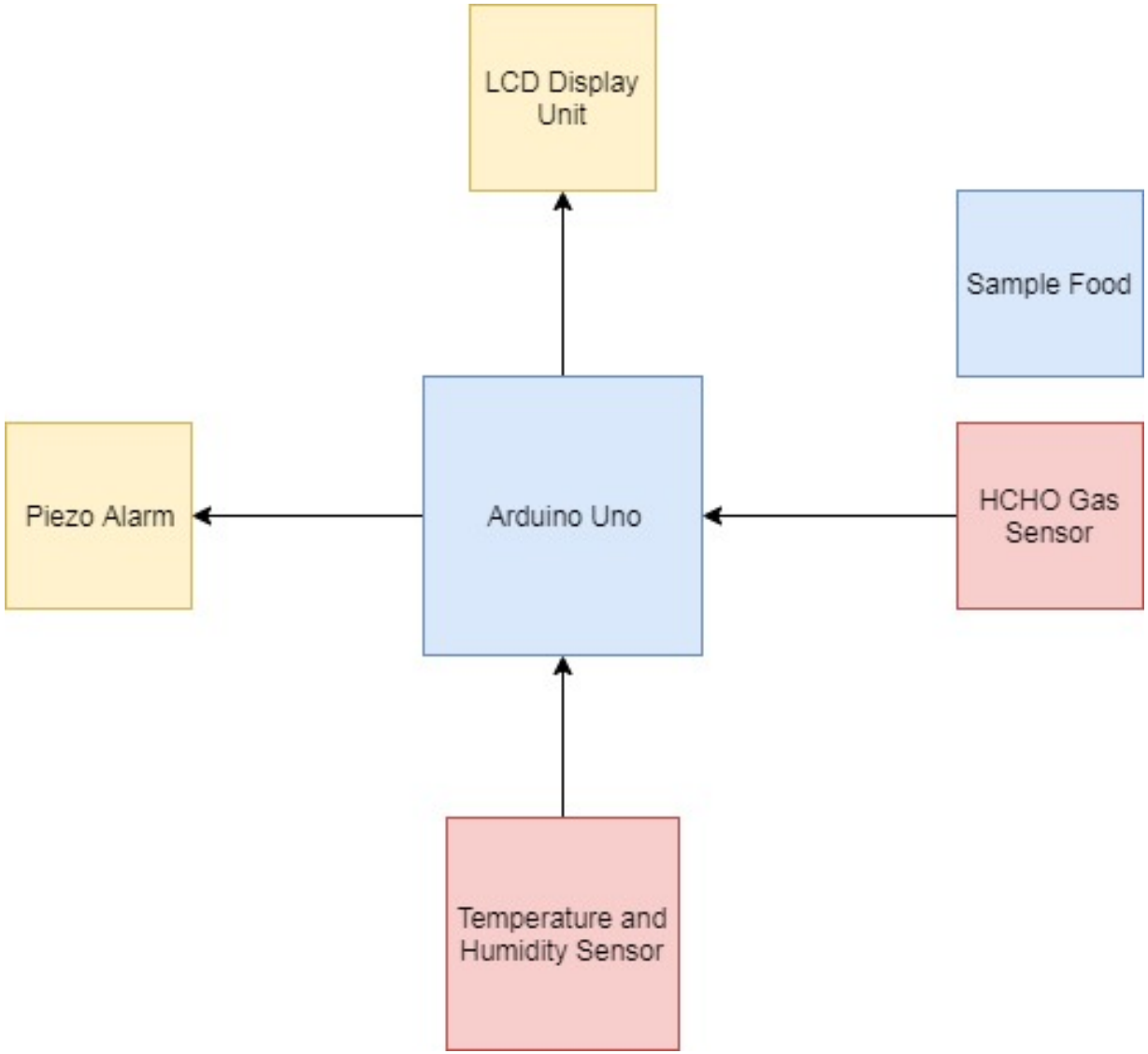

Figure: Block Diagram

Algorithm

- Our sensor checks the increase in conductivity and thereby predicts the concentration. The output is generally from 0.1V to 0.2 V
- We calibrate this value to the normal room temperature level for near perfect readings.
- The microcontroller receives this data and checks it for 2 thresholds of 150ppm and 300ppm
- If less than 150ppm-classified into safe
- If less than 300ppm-classified into unsafe
- If more than 300ppm-classified into Danger

Sensor Specification

- Grove - HCHO Sensor
- Very high sensitivity and stability, concentration till 1ppm.
- Operating Voltage: 5.0V ± 0.3V
- Sensor Resistance Value(Rs): 10K-100K(in 10ppm HCHO)
- Sensitivity: Rs(in air)/Rs(10ppm HCHO)>5

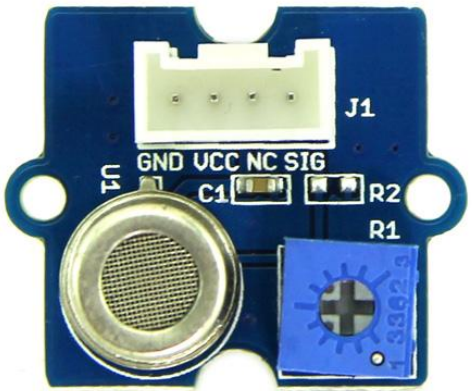

Figure: Grove HCHO Sensor

Zhengzhou Winsen Electronics
Technology Co., Ltd.

Sensor Specification

- DHT11 Temperature Humidity Sensor
- Humidity sensing component, a NTC temperature sensor (or thermistor) and an IC on the back side of the sensor.
- Linear relationship between resistance and temperature as given by- R=kT.

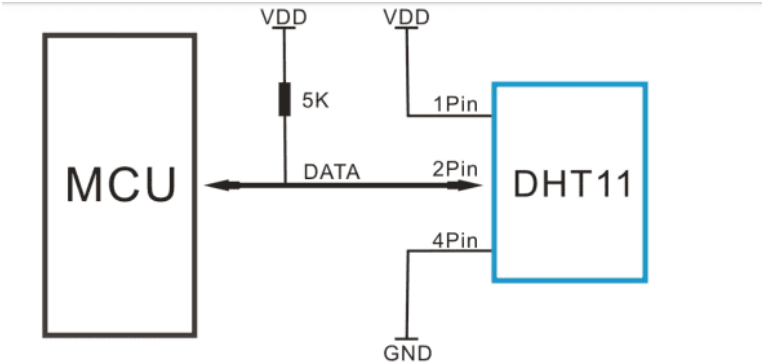

Figure: Circuit Diagram

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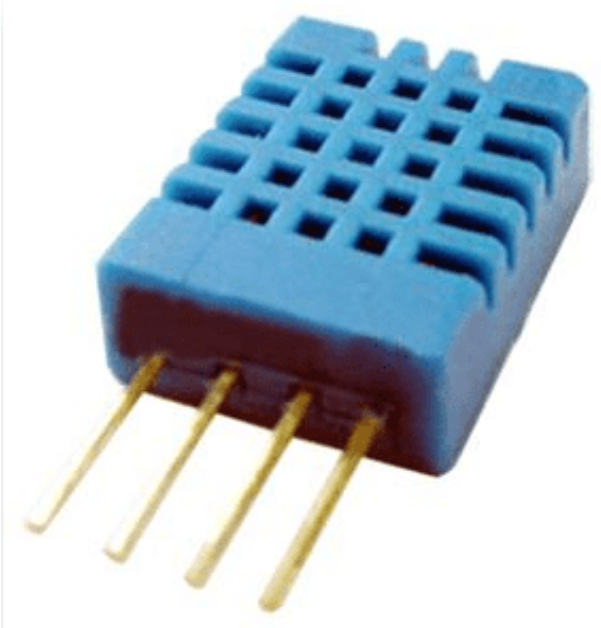

Figure: DHT11 Sensor

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Results

We took readings at room temperature of the surrounding air and a bottle of water to check if the device is working.

Sub	Time	Sensor Value	Concentration	Temp	Humidity
Air	14:12:33	7	1.00	30	60
Air	14: 12:50	6	1.00	30	60
Water	14:13:02	6	3.00	30	60
Water	14:15:08	7	4.00	30	60

Results

1. We tested the device on Ethanol Solutions of different concentration.
2. Formaldehyde was not easily available but ethanol was used instead as it is a suitable replacement.
3. Ethanol is considered a volatile organic compound by the National Pollutant Inventory.
4. We began with a 40% solution of ethanol and kept diluting it.

Results

Table: Ethanol Concentration and Sensor Value (Experiment-1)

Serial No.	Concentration	Sensor Value
1	1 ml 40% C2H5OH	651
2	1 ml 40% C2H5OH + 1ml H2O	563
3	1 ml 20% C2H5OH + 1ml H2O	554
4	1 ml 10% C2H5OH + 1ml H2O	476
5	1 ml 5% C2H5OH + 1ml H2O	398
6	1 ml 2.5% C2H5OH + 1ml H2O	301
7	1 ml 1.25% C2H5OH + 1ml H2O	255
8	1 ml 0.625% C2H5OH + 1ml H2O	203
9	1 ml 0.3125% C2H5OH + 1ml H2O	130
10	1 ml 0.15625% C2H5OH + 1ml H2O	93
11	1 ml 0.078125% C2H5OH + 1ml H2O	86
12	1 ml 0.0390625% C2H5OH + 1ml H2O	74
13	1 ml 0.01953125% C2H5OH + 1ml H2O	63
14	1 ml 0.009765625% C2H5OH + 1ml H2O	63

Results

Table: Ethanol Concentration and Sensor Value (Experiment-4)

Serial No.	Concentration	Sensor Value
1	37% C2H5OH	706
2	37% C2H5OH + 1ml H2O	705
3	18.5% C2H5OH + 1ml H2O	705
4	9.25% C2H5OH + 1ml H2O	658
5	4.625% C2H5OH + 1ml H2O	593
6	2.3125% C2H5OH + 1ml H2O	535
7	1.15625% C2H5OH + 1ml H2O	408
8	0.578125% C2H5OH + 1ml H2O	244
9	0.2890625% C2H5OH + 1ml H2O	203
10	0.14453125% C2H5OH + 1ml H2O	140
11	0.072265625% C2H5OH + 1ml H2O	115
12	0.0361328125% C2H5OH + 1ml H2O	83
13	0.01806640625% C2H5OH + 1ml H2O	68
14	0.009033203125% C2H5OH + 1ml H2O	68

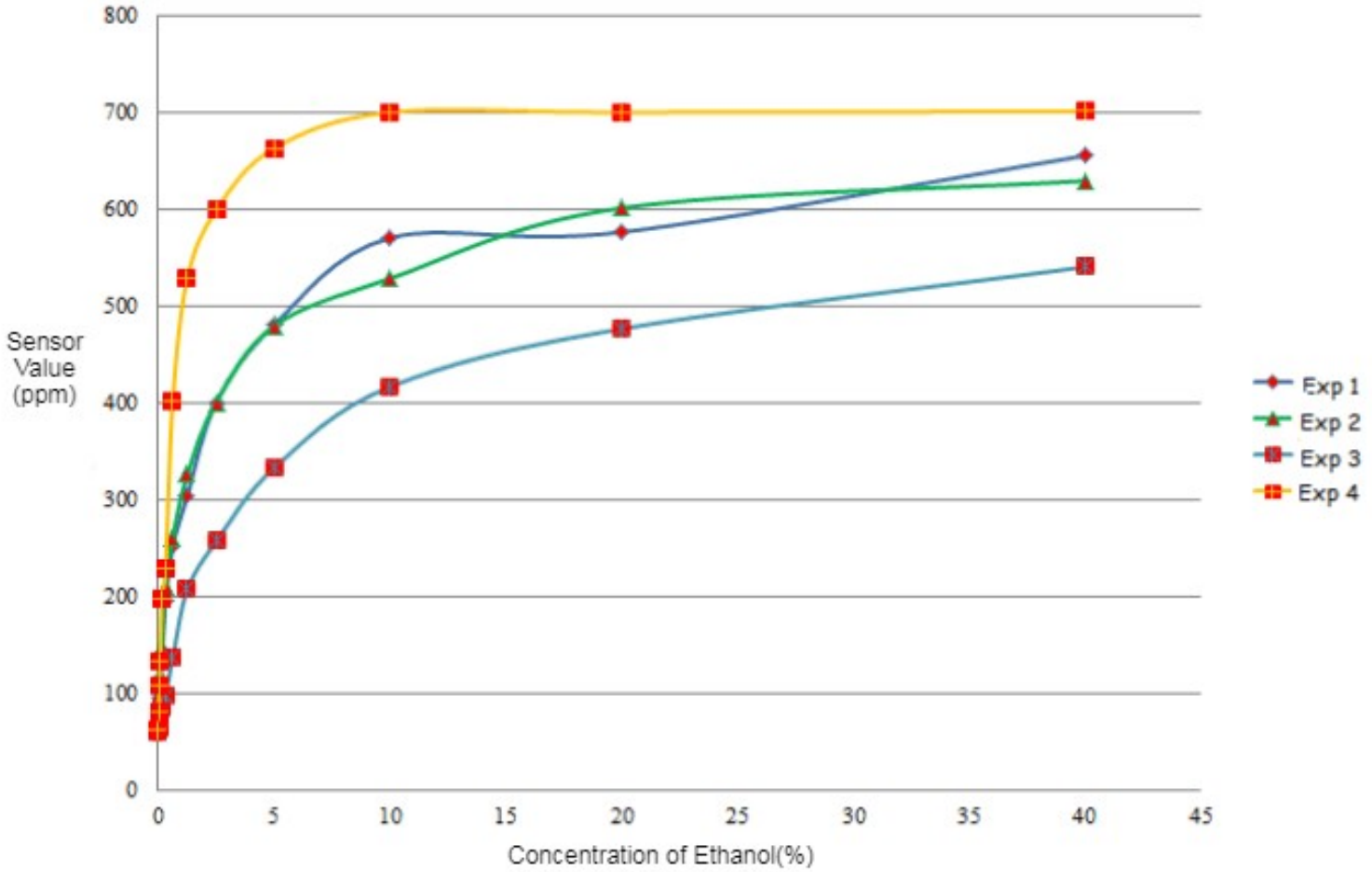
Results

1. Sensor value is found maximum for 40% ethanol which is termed as pure ethanol solution.
2. As the ethanol concentration in the solutions is decreased, the sensor value is also decreased.
3. Sensor values do not start from zero rather they start from 50 to 80ppm which indicates the lowest concentration of ethanol.
4. When the concentration of ethanol is very large, the sensor value goes into saturation and hold a constant value.

Results

Data from all experiments are plotted on a single two dimensional graph.

Figure: Plot



(6).jpg

Results

1. The graph is almost linear when the concentration of ethanol is about 5 to 10%
2. When the concentration of ethanol is above 10%, the concentration of Ethanol vs. Sensor Value graph is a nonlinear one.
3. Here, we defined two different threshold values of the sensor at 150 and 300 ppm.
4. The threshold values can be easily changed in the program to match the national and international safety limits.

Limitations

1. When the concentration of adulterant is too high, the volatile organic compound (VOC) gas sensor cannot show accurate value.
2. The highest saturated value of volatile organic compound (VOC) gas sensor is recorded as 706 units.
3. But as we are concerned with the safety of edible products, this limitation does not cause any problem.
4. Because for much lower concentration of adulterant, the safety limits of foods will be exceeded which can be measured accurately by our kit.

Advantages

1. Low cost due to cheap materials
2. Efficient and accurate Readings
3. Qualitative and quantitative Analysis
4. Easy to use and commercially Viable

Conclusion

1. Our microcontroller-based food adulterant detector kit can detect the concentration level of adulterant present in solid as well as liquid edible samples.
2. It can also determine and display both the humidity and temperature of that sample.
3. This device can help people to be well aware of the safety and the purity of the foods before consumption.

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Thank You