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POST HARVEST DEGRADED ONION AND SEAFOOD DETECTION AND ENVIRONMENT REGULATION SYSTEM

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Abstract: This study introduces a new approach to overcome the limitations of existing methods for testing food freshness, specifically focusing on seafood and onions. By analyzing the volatile organic compounds (VOC) emitted from seafood, the freshness can be accurately determined. An advanced Internet of Things (IoT) system utilizing various sensors was developed to implement this approach. The system effectively detects food ideality, providing valuable information for determining its safety. Moreover, this method contributes to optimizing storage conditions, ensuring longer freshness. Ultimately, the research aims to improve food safety and quality, benefiting consumers and the food industry.

Index Terms **– Volatile Organic Compounds, ideality, freshness, Onion, Seafood.**

I. INTRODUCTION

Globally, around 14 percent of food produced is lost between harvest and retail. [1]. To ensure food safety it should be monitored at every stage of the supply chain. When we harvest the food produce and store it or during the logistics stage of the food produce, the process of decomposition of food initiates. When foods start decaying it produces gases like Carbon dioxide, methane, ammonia, VOCs, etc whose rate of emission increases and these gases accumulate over time.

The goal of this technology is to detect early food rotting before symptoms appear. According to the research, as food decays, it emits particular gases that can be detected by IoT-based sensors, and the levels of these gases fluctuate depending on the extent of the decay.

Literature survey

Vyas et al. (2019) focused on developing a smart onion storage methodology using IoT sensors and devices. The system monitored temperature, humidity, and gas levels to prevent degradation of stored onions. Wang (2018) conducted a Ph.D. thesis on volatile organic compounds emitted from onions during storage. The thesis explored the variations in gas release under different environmental conditions and provided scientific evidence supporting the changes. Ray et al. (2016) presented an IoT-based fruit quality measurement system using apples as an example. An Arduino-based microcontroller board was used to measure ripening indices, and the data was sent to an IoT-based cloud platform for storage and real-time processing. Panda et al. (2019) proposed an IoT retrofitting approach for the food industry to enhance quality checks. They focused on identifying influencing process parameters and integrating a hardware device with a cloud platform for data collection and analysis.

- Wang et al. (2022) proposed a blockchain-enabled fish provenance and quality tracking system using IoT and AI technologies. They developed a multilayer blockchain architecture to ensure trusted and confidential data sharing in fish supply chains.
- Jia and Yang (2011) designed a food quality supervision platform based on the Internet of Things. The platform utilized RFID tags, one-dimensional codes, and ontology-based context modeling to meet the requirements of food quality supervision.
- Keshavamurthy et al. (2019) developed an automated food quality detection and processing system using neural networks. They used OpenCV and CNN to recognize fruit types and detect their quality, while also monitoring storage conditions via IoT technology.
- The European Commission's Annex 5 on Controls on total volatile basic nitrogen (TVB-N) provides international standards for permissible TVB-N limits in unprocessed fishery products for human consumption.

II. WORKING MODEL

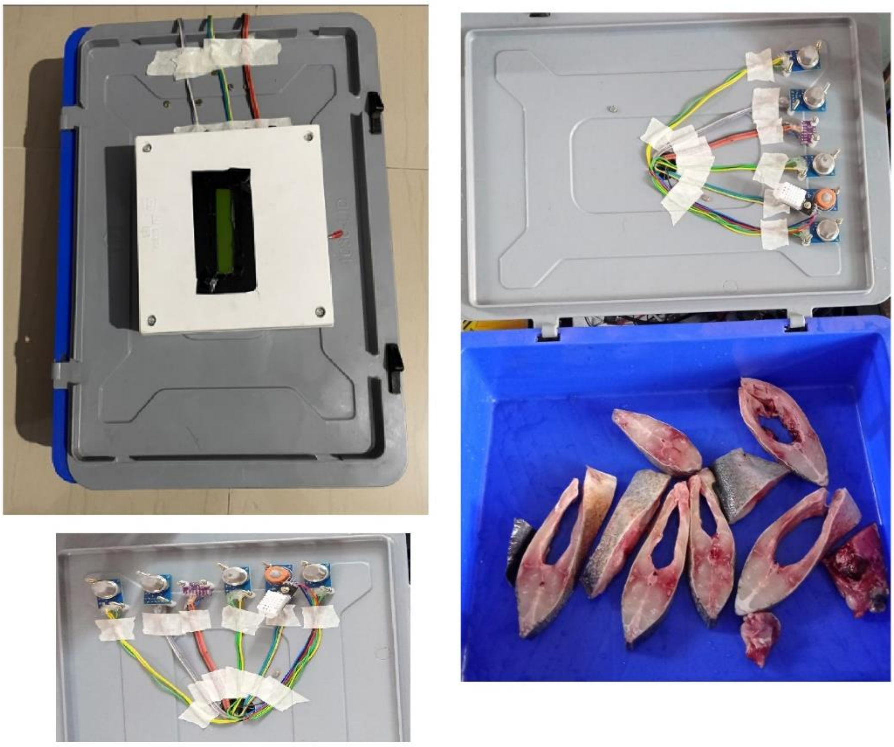


Figure 01: Post Harvest Degraded Onion and Seafood Detection and Environment Regulation System (Working module)

The above-designed model consists of a container for the storage of food. Many distinct gaseous sensors are affixed on the inner face of the container's lid. A plastic container is fixed on the outer face of the lid. This box contains the ESP32 board, the buzzer, the relay, and the electrical wired connections. The outer face of the box container has an LCD screen mounted to it which displays the real-time emissions of various gases. -

III. SYSTEM ARCHITECTURE

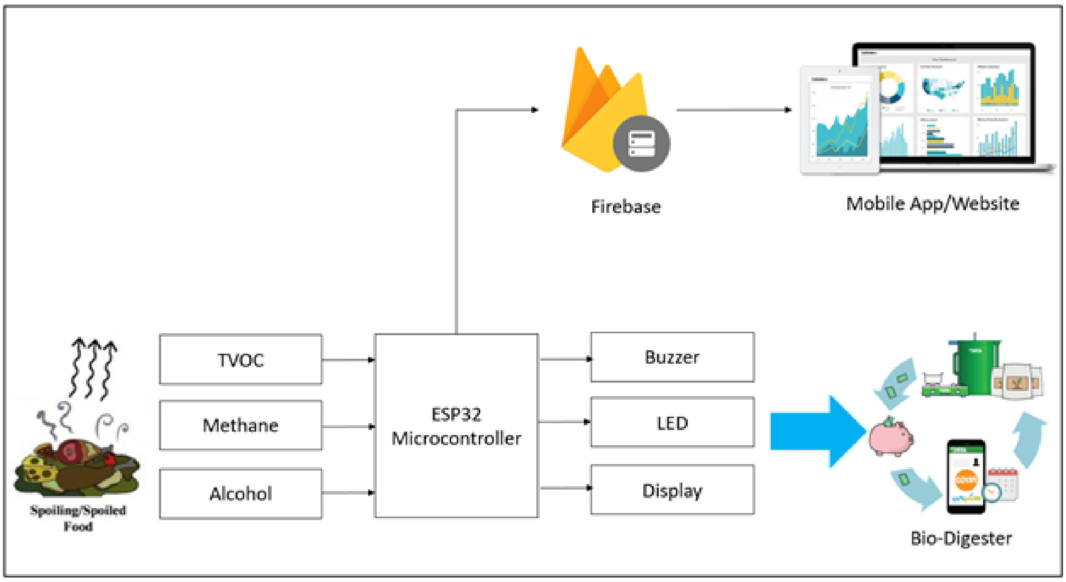


Figure 02: System Architecture

The system architecture begins with the placement of food, which emits volatile gases. Sensors, including analog and digital sensors, are deployed on the hardware to detect these gases. The sensor data is then transmitted to the ESP32 Development Board.
Upon receiving the sensor data, the microcontroller processes it and triggers various outputs. This includes activating an LED, sounding a buzzer, and displaying the emission rates of different gases on a 16 X 2 LCD Display.

Simultaneously, the microcontroller sends the received data to Google Firebase, a cloud-based database service. This enables real-time remote access to the data. Firebase then transmits the data to a web interface that has been created specifically for this system. In the web interface, real-time results are presented in the form of graphs and charts. This allows users to visualize the emission rates of different gases over time.

In order to regulate the Environmental conditions an emphasis is given to the temperature aspect dedicatedly to Onions. When the system detects that the present temperature range varies from the ideal temperature range, then an alert is sent to the user. Also, the fan mounted on the system turns ON gradually leading to calibrating the temperature back to its ideal set count, Ensuring a nourishing environment for the food stored in the system.

Overall, the system architecture ensures that the volatile gas emissions from the food can be detected, processed, displayed locally, and also made accessible remotely in real-time through Firebase and a web interface.

IV. HARDWARE AND SOFTWARE REQUIREMENTS

To develop the proposed system, various hardware, software, and Data resources were gathered.

The Hardware components include:

- ESP32 Microcontroller Development Board
- MQ-2 Methane & flammable gases Sensor
- MQ-135 Air quality sensor
- MQ-137 Ammonia Sensor
- ATmega328L
- Relay
- DC 12V Cooling Fan
- CCS811 TVOC Gas Sensor
- MQ-3 Alcohol Sensor
- MQ-136 Hydrogen Sulphide Sensor
- DHT-22 Temperature & Humidity Sensor
- 16 X 2 LCD Display
- Buzzer
- LED

The Software entities include:

- Arduino IDE
- Google Firebase

V. METHODOLOGY

The methodology of this research project is divided into twelve sections. Firstly, the problem of spoiled food products and its impact on the industry was identified, and the scope of the project was defined to focus on detecting spoiled seafood and onions using biosensors and gaseous properties. Thorough research was conducted to select suitable sensors, considering factors like accuracy, range, sensitivity, cost, and compatibility. The hardware development involved designing and integrating the selected sensors with the ESP32 microcontroller, ensuring proper circuitry and connections. Software development included implementing algorithms for data processing, classification of spoiled food items, and detection of TVOCs, ethanol, and harmful gases, along with creating a web application for user monitoring.

Extensive testing and calibration were performed to ensure accurate detection and functionality of the system. Cloud integration involved setting up a cloud-based database service for data storage and communication between the microcontroller and the cloud server. A web interface was developed to display real-time results and visualizations of gas emission rates. The integrated system underwent final testing and deployment in relevant environments. Data analysis included collecting standard reference data, analyzing sensor data using statistical techniques, generating reports, and providing insights and recommendations.

Overall, this methodology provides a detailed and systematic approach for the detection and monitoring of spoiled food products, incorporating hardware development, software implementation, data analysis, and user interface design.

VI. ALGORITHM

1. Start
2. Initialize the LCD display, CCS811 sensor, DHT sensor, and other variables and constants.
3. Set up the serial communication.
4. Check if the CCS811 sensor is successfully started. If not, display an error message and stop the program.
5. Set the pin Mode for the buzzer and fan as OUTPUT.
6. Begin the DHT sensor.
7. Wait for the CCS811 sensor to be available.
8. Clear the LCD display.
9. Read sensor values from the Alcohol, Ammonia, Methane, Nitrogen, and Sulphide sensors using the analogRead() function.
10. Convert the sensor values to corresponding parts per million (ppm) values.
11. Print the Alcohol and Ammonia values on the LCD display.
12. Delay for 3 seconds.
13. Clear the LCD display.
14. Print the Methane and Nitrogen values on the LCD display.
15. Delay for 3 seconds.
16. Clear the LCD display.
17. Print the Sulphide value on the LCD display.
18. Delay for 3 seconds.
19. Clear the LCD display.
20. Print the CO2 and TVOC values on the LCD display.
21. Delay for 3 seconds.
22. Clear the LCD display.
23. Read the Humidity and Temperature values from the DHT sensor.
24. Print the Humidity and Temperature values on the LCD display.
25. Delay for 3 seconds.

26. Map the sensor values to a range of 0 to 1023.
27. Check if the humidity value is above 60%. If true, turn on the fan; otherwise, turn it off.
28. Check if any of the sensor values exceed the threshold values. If true, turn on the buzzer; otherwise, turn it off.
29. Store the sensor values and other data in the Firebase database.
30. Redirect the data from Firebase to Web Interface for displaying visual results
31. Repeat the loop.
32. finish

VII. FLOWCHART

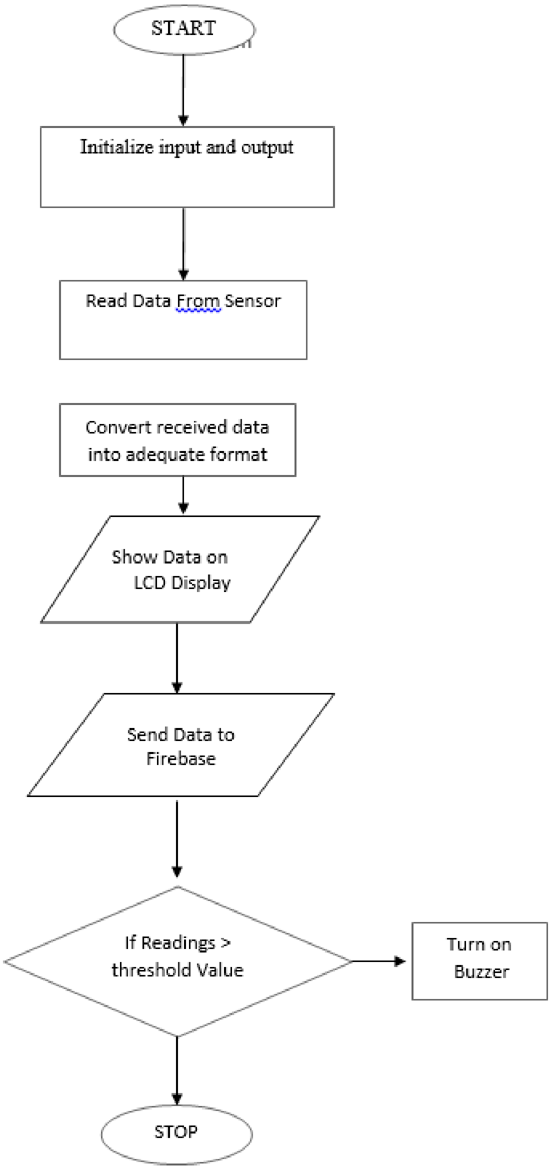


Figure 03: Flow Chart

VIII. RESULT

8.1 Representation of Results on hardware

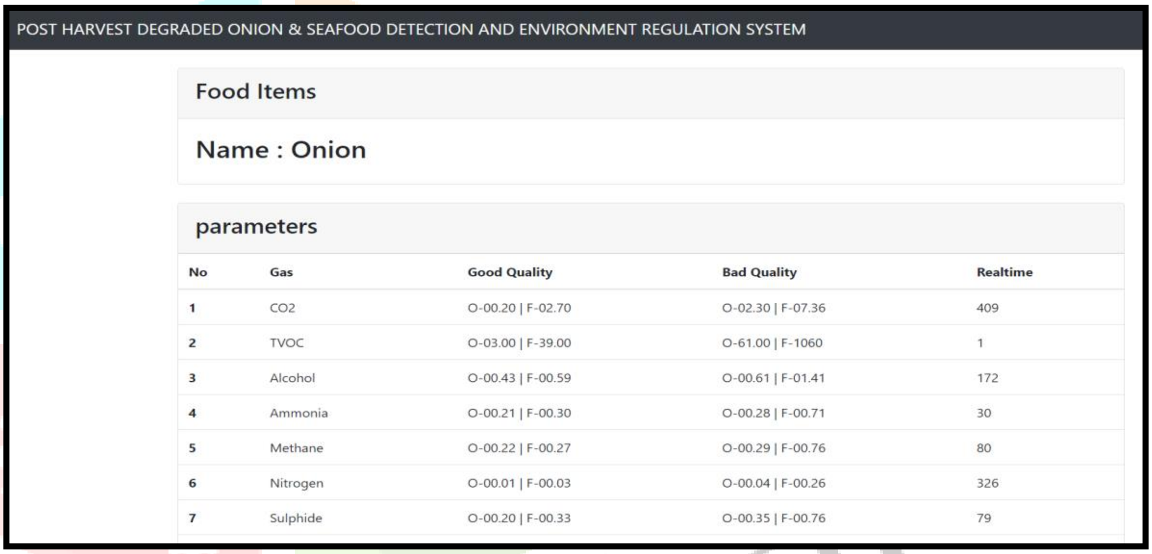
Figure 04: Emission from Healthy Onions

Figure 05: Emission from Deteriorated Onions

Figure 06: Emission from Healthy Seafood

Figure 07: Emission from Deteriorated Seafood

8.2 Representation of Results Web Interface



POST HARVEST DEGRADED ONION & SEAFOOD DETECTION AND ENVIRONMENT REGULATION SYSTEM

Food Items

Name : Onion

parameters

No	Gas	Good Quality	Bad Quality	Realtime
1	CO2	O-00.20 | F-02.70	O-02.30 | F-07.36	409
2	TVOC	O-03.00 | F-39.00	O-61.00 | F-1060	1
3	Alcohol	O-00.43 | F-00.59	O-00.61 | F-01.41	172
4	Ammonia	O-00.21 | F-00.30	O-00.28 | F-00.71	30
5	Methane	O-00.22 | F-00.27	O-00.29 | F-00.76	80
6	Nitrogen	O-00.01 | F-00.03	O-00.04 | F-00.26	326
7	Sulphide	O-00.20 | F-00.33	O-00.35 | F-00.76	79

Figure 08: Representation of real-time results in the form of a Chart

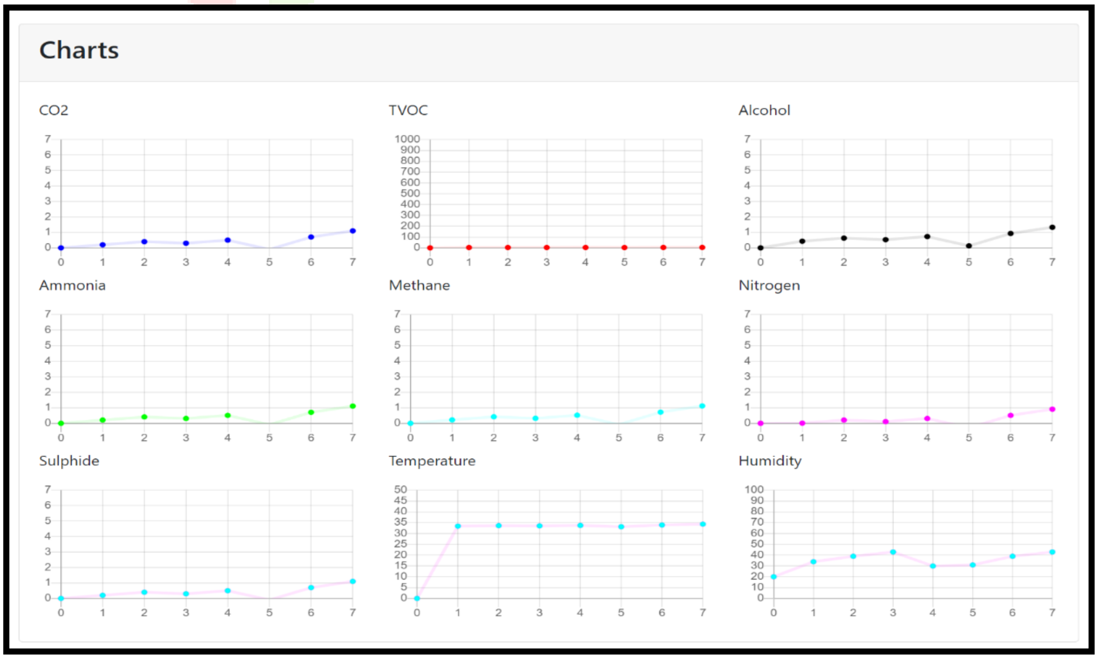


Figure 10: Representation of real-time results in the form of Graphs

The variation in the emission of the various volatile gases detected by the system can be remotely observed in real-time in the form of Graphs &Chart by the user. It also indicates the variation in temperature & humidity over time. The real-time readings are compared with the ideal food quality readings on the chart.

8.3 Conclusion over Performance Parameters

Table 01: Volatile Emissions from Onion (*Allium Cepa*)

Gas	Fresh Emission	Healthy Emission	Deteriorated Emission
Co2	0.20 PPM	1.23 PPM	2.30 PPM
TVoC	3.00 PPM	27 PPM	61.0 PPM
Alcohol	0.43 PPM	0.54 PPM	0.61 PPM
Ammonia	0.24 PPM	0.24 PPM	0.30 PPM
Methane	0.22 PPM	0.25 PPM	0.29 PPM
Nitrogen	0.01 PPM	0.02 PPM	0.04 PPM
Sulphide	0.20 PPM	0.27 PPM	0.35 PPM

Table 02: Volatile Emissions from Seafood

Gas	Fresh Emission	Healthy Emission	Unhealthy Emission
Co2	2.70 PPM	5.07 PPM	7.36 PPM
TVoC	39.0 PPM	84 PPM	106 PPM
Alcohol	0.59 PPM	0.9 PPM	1.41 PPM
Ammonia	0.30 PPM	0.52 PPM	0.71 PPM
Methane	0.27 PPM	0.51 PPM	0.76 PPM
Nitrogen	0.03 PPM	0.15 PPM	0.26 PPM
Sulphide	0.33 PPM	0.53 PPM	0.76 PPM

The above readings were obtained after conducting a considerable number of test cases for Onion and Seafood.

IX. CONCLUSION

The use of electrical and biosensors in the detection of food deterioration has the potential to significantly reduce the prevalence of foodborne illnesses. These sensors allow for the detection of naturally occurring gases as well as the monitoring of essential elements like moisture levels and volatile organic compounds, providing early warning signs of food decomposition even before outward symptoms appear. The integration of these sensors is made feasible and effective by tools like the ESP32, making it easier to identify spoiled domestic food items like dairy, fruits, and more. Additionally, the integration of physical tools and web applications improves usability and accessibility, enabling users to easily judge the caliber and freshness of their food.

Additional research in this area may result in the addition of other gas sensors and an increase in the types of food that may be detected, increasing the sensitivity and precision of the detection techniques. By enabling early spoiling detection and preventing the consumption of contaminated food, such developments have the potential to completely transform current food safety procedures. This strategy helps to a healthier society and lowers the risk of foodborne illnesses by giving people the tools they need to make knowledgeable decisions about their food consumption.

X. FUTURE WORK SUGGESTED:

The avenues for future work to enhance the food quality prediction system are as follows:

- Expand the system's scope to include a wider range of food items such as fruits, vegetables, meat, and dairy products. Incorporate specific sensors and data analysis techniques for each type of food to provide comprehensive quality insights.
- Improve accuracy by integrating advanced machine learning and deep learning techniques. Train the system with larger datasets and utilize more complex algorithms to enhance prediction capabilities and ensure precise and reliable quality predictions.
- Develop a dedicated mobile application that allows users to scan QR codes or barcodes on food packaging. The application would provide instant quality predictions, making it convenient for consumers to make informed decisions while shopping or assessing their food items at home.
- Incorporate a user feedback mechanism to gather insights and refine the system. Implement a rating system or comments section to collect feedback on quality predictions, enabling continuous fine-tuning of algorithms based on real-world user experiences.

These future work suggestions aim to transform the system into a comprehensive and accurate tool for assessing food quality, improving user accessibility, and promoting safer and healthier food consumption practices.

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