IOT-BASED FOOD SPOILAGE DETECTION SYSTEM WITH UV STERILIZATION

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ABSTRACT: **In the context of the COVID-19 pandemic, ensuring food safety and minimizing waste has become a critical concern. This project presents an IoT-based solution for detecting food spoilage and providing UV sterilization to extend the edibility of food items. The system utilizes a Node MCU microcontroller integrated with an MQ-135 gas sensor, DHT11 temperature and humidity sensor. When food is placed near the MQ-135 gas sensor, the sensor detects the levels of spoilage- indicating gases such as ethanol. If the gas concentration exceeds a predefined threshold, the system alerts the user by illuminating a red LED. The system then suggests UV sterilization to eliminate harmful microorganisms, making the food safe for consumption. A UV lamp is activated for a specified duration to sterilize the food, thereby reducing the risk of foo d borne illnesses. An accompanying mobile application provides real-time monitoring of sensor values, including gas levels, temperature, and humidity. The app notifies the user when spoilage is detected and guides them through the sterilization process. This integrated approach ensures that food, even on the verge of spoilage, can be safely consumed after appropriate sterilization, thus reducing food waste during times when access to fresh supplies may be limited.**

Keywords: *Node MCU, MQ-135 Gas Sensor, DHT11 Sensor IR Sensor, UV Sterilization, Food Safety, IoT*

I. INTRODUCTION

Food spoilage is a significant concern in the food industry, leading to economic losses and public health risks. Traditional methods of monitoring food freshness rely on visual inspection or manual checks, which are often subjective and prone to errors. With the advent of IoT (Internet of Things) technology, there is an opportunity to revolutionize food spoilage detection by enabling real-time monitoring and proactive intervention.

In this paper, we propose an IoT-based system for food spoilage detection integrated with UV sterilization. The system aims to address the shortcomings of existing methods by providing continuous monitoring of key parameters such as temperature, humidity, and gas composition within food storage environments. Additionally, UV sterilization modules are incorporated into the system to combat microbial contamination and extend the shelf life of perishable items.

By leveraging IoT sensors and data analytics, our system enables timely detection of food spoilage, allowing for preventive measures to be taken before significant deterioration occurs. Moreover, the integration of UV sterilization adds an extra layer of protection against harmful microorganisms, enhancing food safety and reducing the risk of food borne illnesses.

This paper presents a detailed description of the proposed system architecture, including the hardware components, communication protocols, and data processing algorithms. Furthermore, we discuss the implementation challenges and potential applications of the system in various food storage settings, such Warehouses, supermarkets, and households. Overall, our research contributes to the advancement of food preservation technologies by harnessing the power of IoT and UV sterilization to ensure the freshness and safety of food products throughout the supply chain.

A. ***Objectives Of The Proposed Works***

The objectives of the proposed work are to:

1) Develop an IoT-based system for real-time monitoring of food storage conditions.
2) Integrate sensors to detect environmental parameters such as temperature, humidity, and gas levels.
3) Implement machine learning algorithms to analyze sensor data and detect patterns indicative of foodspoilage.
4) Incorporate UV sterilization technology for automated disinfection upon spoilage detection.
5) Evaluate the effectiveness of the system in prolonging food shelf life and reducing spoilage through empirical testing.
6) Design a user-friendly interface for stakeholders to interact with the system and receive time alerts.

II. LITERATURE SURVEY

Integrating IoT with UV sterilization offers a promising method to improve food safety and extend shelf life. IoT technologies, such as wireless sensors and cloud computing, enable real-time monitoring of food conditions. Sensors can detect spoilage indicators like gases and pH changes.To address these issues, numerous studies have investigated innovative approaches for detecting spoilage and extending the shelf life of perishable food items. In this literature survey, we explore the current landscape of research and technologies in the areas of food spoilage detection and UV sterilization. By reviewing existing literature, we aim to gain insights into the effectiveness of various methods and technologies employed to mitigate food waste and ensure food safety.

Additionally, we examine the role of IoT technology in revolutionizing food management practices, particularly in real-time monitoring and intervention. Through this survey, we seek to identify gaps, opportunities, and emerging trends that can inform the development of our proposed IoT - based system for food spoilage detection with UV sterilization. UV sterilization is a widely researched method for inhibiting microbial growth, extending the shelf life of food products. This literature survey explores the intersection of these two areas: the detection of food spoilage and the role of UV sterilization in mitigating it.UV sterilization, which uses ultraviolet light to kill bacteria and viruses, helps reduce contamination and keep food fresh longer. Research by Sharma et al. (2018) and Lee et al. (2019) shows the effectiveness of UV light in food preservation. Combining these technologies, Zhang et al. (2021) developed a smart fridge that uses sensors and UV light to detect spoilage and reduce microbial load, ensuring better food quality and safety.

A. ***Detection of Food Spoilage***

1) Traditional Methods: Traditional Methods includes Sensory Evaluation and Microbial Analysis. These methods are accurate but time-consuming and require specialized equipment.

2) Advanced Detection Techniques: Advanced Detection Techniques includes Chemical Sensors and Bio-Sensors, Spectroscopic Methods, Imaging Techniques.

3) UV Sterilization In Food Preservation: UV Sterilization In Food Preservation where UV-C Light (200-280 nm): Involves assessing changes in appearance, odor, and texture. While widely used, it is subjective and not always reliable.

III. METHODOLOGY

Food spoilage detection and alerting system is used to detect and alert the user whether the food material is spoiled or not. The block diagram shows the through and flows of the system and also explains the operation of the system. When the system is initialized and on, it measures the present atmospheric values. When the food material is kept near the sensors, the sensors arranged in the system will continuously sense the readings from the food material and then the readings are transferred to the Arduino board which analyzes the data according to the stored threshold conditions written in Arduino IDE and communicate to the output devices to show the result through serial manner. When the sensed food material is spoiled it gives a beeping buzz and also a red led will glow along with an email alert stating “food is spoiled”. When the sensed food material is not spoiled a green led will glow and LCD will display “food is not spoiled.”

IV. PROPOSED SYSTEM

The proposed systems for ”IoT-Based Food Spoilage Detection with UV Sterilization” represent a comprehensive approach to addressing the challenges of food storage management. By integrating IoT technology and UV sterilization systems, these methods aim to revolutionize food safety practices and minimize waste throughout the food supply chain. Through continuous monitoring of environmental parameters, detection of spoilage events, and automated sterilization processes, the proposed systems provide proactive solutions to preserve food quality and extend shelf life.

A. Block Diagram

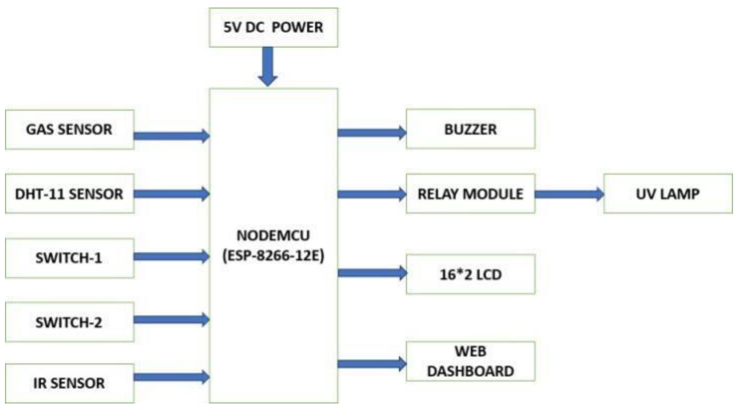
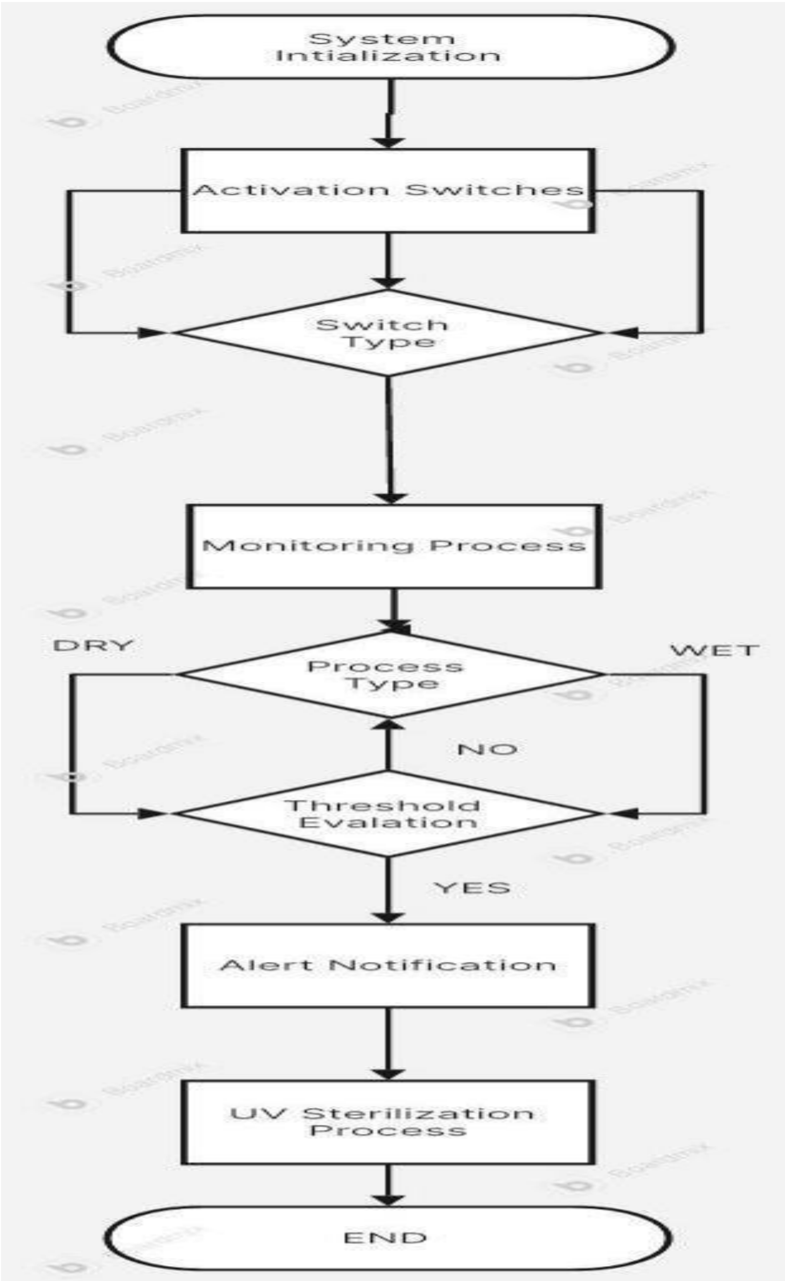


Fig: Proposed Block Diagram

In this system we will monitor weather parameters like gas emission based on the food spoilage. For this purpose we have used MQ gas sensor. This sensor calculates emission of gases and gives digit output to the controller with inbuilt Wi-Fi. These all sensors will connect to the Node MCU controller which will take sensors data and display them in the Blynk app.

B. Flow chart



V. RESULTS

A. When Wet Switch Is On

When the wet switch is turned on, the monitoring program for wet food items (e.g..bananas) is activated. The ethylene gas sensor begins to measure the ethylene concentration in the environment around the bananas.

Table: Comparison of spoilage detection parameters for bananas between current and previous projects.

Spoilage Stage	Current Project Temperature (°C)	Current Project Humidity (%)	Current Project Ethylene Concentration (ppm)	Previous Project Temperature (°C)	Previous Project Humidity (%)	Previous Project Ethylene Concentration (ppm)
Fresh	13-15	85-90	1-2	12-14	80-85	0.1-0.2
Fresh	13-15	85-90	2-5	12-14	80-85	0.1-0.2
Early Spoilage	15-18	90-95	15	14-17	85-90	0.3-0.8
Early Spoilage	15-18	90-95	25	14-17	85-90	0.3-0.8
Early Spoilage	15-18	90-95	40	14-17	85-90	0.3-0.8
Spoiled	22-25	85-90	55	21-24	80-85	8.0-20.0
Spoiled	22-25	85-90	120	21-24	80-85	>20.0

B. When Dry Switch Is On

When the Dry switch is turned on, the monitoring program for dry food items (e.g., onions) is activated. The ethylene gas sensor begins to measure the ethylene concentration in the environment around the onion.

Table: Comparison of spoilage detection parameters for onions between current and previous projects

Spoilage Stage	Current Project Temp (°C)	Current Project Humidity (%)	Current Project Ethylene (ppm)	Previous Project Temp (°C)	Previous Project Humidity (%)	Previous Project Ethylene (ppm)
Fresh	0-5	70-75	0.1-1	10-12	60-65	0-10
Slightly Spoiled	5-10	75-80	1-5	12-15	65-70	10-20
Early Spoiled	10-15	80-85	5-10	15-20	70-75	20-30
Moderate Spoilage	15-20	85-90	10-20	20-25	75-80	30-40
Advanced Spoilage	20-25	90-95	20-30	25-30	80-85	40-50
Severe Spoilage	25-30	95-100	30-50	30-35	85-90	50-60
Rotten	>30	>95	>50	>35	>90	>60

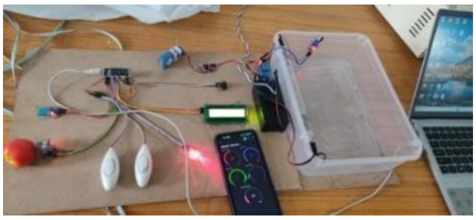


Fig: Project kit

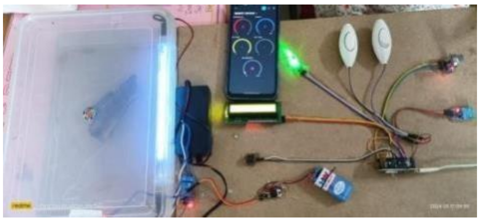


Fig: UV Sterilization Process

Fig: Kit Initialization

(Before Food Detected)

Fig: Alert to go for UVSterilization

(After Food Detected)

VI. ADVANTAGES

1. Fruit Freshness: IoT monitoring and UV sterilization extend fruit shelf life, reduce spoilage, and enhance quality.

2. Reduced Wastage: Effective environmental monitoring minimizes food wastage and promotes sustainable practices.

3. Energy-Efficient UV Sterilization: Automated control saves energy and optimizes sterilization effectiveness.

4. Remote Monitoring and Control: IoT technology enables remote management and optimization of storage conditions.

5. Overall Impact: Prolonged freshness, reduced wastage, energy efficiency, and remote monitoring enhance fruit storage efficiency and competitiveness.

VII. DRAWBACKS

Some concise drawbacks of an IoT-based food spoilage detection system with UV sterilization:

- High initial cost
- Complexity in setup and maintenance
- Increased power consumption
- Reliability issues with connectivity
- Limited effectiveness against all pathogens

- Safety concerns with UV radiation
- Ongoing maintenance requirements

VIII. FUTURE SCOPE

This project can be further improved to detect small amount of spoiled food area using Nano technology. Since this project is confined to only solid food materials. In future it can Be extended or modified to detect both solid and liquid food materials. It can also modified to Include high precision sensors for wide area of operation to detect the food materials. We can Also extend this project to implement artificial intelligence techniques to detect the specific Area of food spoilage in the total food quantity. Specific The need for food safety and waste reduction is a global concern, presenting opportunities for The widespread adoption of IoT-based solutions across diverse regions and economies. Whether In developed countries with stringent food safety regulations or in emerging markets where Food security is a priority, these systems can address common challenges and improve overall Food management practices.

IX. CONCLUSION

In conclusion, this IoT-based solution offers a novel approach to enhancing food safety and reducing waste during the COVID-19 pandemic and beyond. By leveraging the capabilities of the Node MCU microcontroller integrated with MQ-135 and DHT11 sensors, the system effectively monitors spoilage-indicating gas levels, temperature,and humidity in real-time. The incorporation of UV sterilization technology provides an additional layer of safety, allowing potentially spoiled food to be made safe for consumption, thereby addressing both health and sustainability concerns.

The practical implementation of this system demonstrates significant potential in ensuring food security, particularly in scenarios where access to fresh food supplies is restricted. The mobile application enhances user interaction by providing timely alerts and detailed guidance on monitoring and sterilizing food items. This user- friendly interface ensures that even individuals with minimal technical expertise can benefit from the system's features.

Overall, the integration of real-time monitoring, spoilage detection, and UV sterilization presents a comprehensive solution to food spoilage challenges. This approach not only minimizes food waste but also mitigates the risk of foodborne illnesses, contributing to public health safety. Future improvements could include refining sensor accuracy, expanding the range of detectable spoilage indicators, and integrating additional IoT functionalities for a more robust food safety system. The ongoing development and adoption of such technologies are crucial in addressing food security and sustainability challenges, particularly in times of crisis like the COVID-19 pandemic.

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