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QUALITY MONITORING OF FRUITS AND VEGETABLES USING IoT

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Abstract: Food security, economic stability, and public health are all greatly impacted by food safety and quality. In addition to causing serious illnesses, spoiled or infected food contributes significantly to food waste. Innovative approaches that integrate affordability, accuracy, and efficiency are needed to address these issues. The creation and deployment of Internet of Things (IoT)-based food quality monitoring systems that use inexpensive sensors to identify early spoiling indicators are the main topics of this review. In particular, the MQ4 methane sensor's interaction with NodeMCU and Wi-Fi modules offers a reliable way to keep an eye on gases released during food decomposition, such as ethanol and methane. In order to guarantee food safety, these devices provide real-time data to cloud-based platforms like the Blynk app, allowing for remote monitoring and prompt response.

These systems' main goal is to improve food quality monitoring by spotting rotting indicators long before outward symptoms show up. These systems enable users to take preventive action, lowering the risk of foodborne infections and limiting food waste by providing real-time data and notifications. In large-scale settings where manual inspection is laborious and inefficient, including storage facilities, warehouses, and supermarkets, this method is very advantageous. These devices enhance general food management procedures in homes by giving users a quick and simple way to check the freshness of food that has been stored.

Furthermore, improvements in sensor technology have made it possible to detect spoiling with greater accuracy and dependability. Multi-parameter sensors provide a complete solution for evaluating the quality of food since they can track several environmental parameters at once. This innovation contributes to more sustainable and effective food handling by guaranteeing wider applicability, from industrial food processing to personal use.

IoT-based food monitoring systems support international sustainability objectives by tackling important problems in food safety and waste management. They offer an affordable, scalable way to lower food spoilage, boost consumer confidence, and advance public health. In order to encourage safer, healthier, and more effective food storage methods in a variety of settings, this study emphasizes how crucial it is to implement these systems.

Keywords: Food waste reduction, foodborne illness prevention, food quality evaluation, sensor technology advancements, gas emission detection, sustainable food management, smart food storage solutions, IoT-based monitoring, food spoilage detection, MQ4 methane sensor, NodeMCU integration, real-time monitoring, cloud-based platforms, and food safety.

I. INTRODUCTION

Public health and economic stability depend heavily on food safety and quality; however, contamination and spoiling are becoming more problems. Microbial activity and environmental variables cause food to spoil, which not only results in significant waste but also poses a considerable risk to human health through foodborne infections. Recent research indicates that methane and ethanol are important markers of food deterioration,

Technology developments, especially the Internet of Things (IoT), provide creative ways to monitor food quality in a world where food security is a major concern. IoT-based solutions combine wireless connectivity, sensors, and microcontrollers to give customers real-time data on spoiling characteristics, allowing them to identify and stop food degradation early. The efficiency of NodeMCU and MQ4 methane sensors in identifying gas emissions from damaged food has made them popular. By sending data to cloud-based platforms, these devices enable remote monitoring via apps like the Blynk app, which gives consumers useful insights.

This paper looks at how IoT-based food quality monitoring systems can help with the dual problems of waste reduction and food safety. It investigates how inexpensive sensors, wireless modules, and intuitive user interfaces might be combined to produce scalable and useful solutions for a range of environments, such as homes, supermarkets, and storage facilities. The study also covers the developments in sensor technology that improve the precision and dependability of food quality evaluations, supporting more sustainable and healthful food management techniques.

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These systems provide a promising route to a more sustainable future by utilizing technology to guarantee the safety and freshness of food, supporting international initiatives to decrease food waste and increase food security.

II. LITERATURE SURVEY

[1] . Using NodeMCU and integrating sensors like DHT-11, MQ4, and LDR, B. Ravi Chander, P.A. Lovina, and G. Shiva Kumari (2020) created an Internet of Things-based food quality monitoring system. Temperature, humidity, and gas concentrations were among the environmental characteristics that these sensors tracked. An ESP8266 Wi-Fi modem was used to send the collected data to an IoT platform for real-time monitoring. By preserving ideal storage conditions, the method decreased food waste and allowed for early spoiling detection.

[2] Suruchi Parmar, Tejaswini Manke, and Neha Badhan (2020) introduced a system for detecting food freshness by monitoring ethanol and pH levels. They employed a pH-based technique to assess milk deterioration and a MQ3 sensor to detect the amount of ethanol present in bananas. This system's efficacy in food safety applications was demonstrated by the early alerts it offered to avoid foodborne diseases.

[3] Naveed Shahzad and Usman Khalid (2018) proposed the EFresh device, which employed biosensors and electrical sensors to evaluate food freshness. It measured parameters such as moisture content and hydrogen ion concentration and provided real-time freshness assessments accessible via an Android application. The system achieved significant improvements in detecting spoilage for fruits and meats.

[4] Using gas sensors and RFID technology, Ki Hwan Eom and Min Chul Kim (2012) put in place a system for monitoring the freshness of vegetables. The device detected changes in vegetable freshness by measuring oxygen and carbon dioxide concentrations, providing excellent precision and usefulness for large-scale supply chain and logistical applications.

[5] Jessie R. Balbin, Julius T. Sese, and Crissa Vin R. Babaan (2017) developed a system employing an electronic nose and machine learning algorithms to detect bacterial contamination in street food. The use of moisture and gas sensors, combined with a support vector machine, ensured precise classification of bacterial presence, contributing to enhanced food safety.

[6] In 2020, Alexandru Popa, Mihaela Hnatiuc, and Mirel Paun presented a low-cost sensor-based IoT-enabled food quality monitoring system. Temperature, humidity, and other environmental parameters were continuously measured by the system, which sent the data to cloud platforms. This method offered practical advice for maximizing food preservation and reducing spoiling in both commercial and residential contexts.

III. OVERVIEW OF SYSTEM

A. Block Diagram

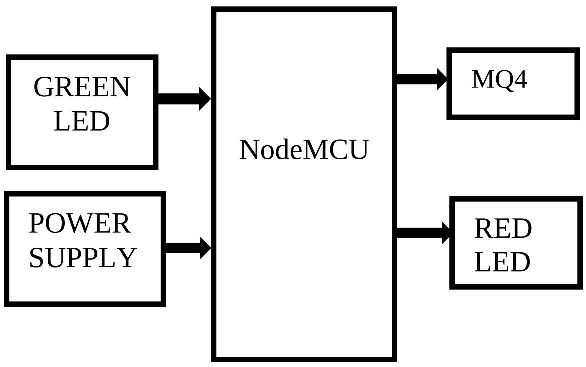

Fig 1: Block diagram of system

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The proposed system is a comprehensive IoT-based solution designed to monitor the quality and freshness of fruits and vegetables in real time. It combines advanced sensor technologies with the capabilities of a microcontroller to detect spoilage gases and provide timely notifications to users, thereby reducing food waste and ensuring safety. The system primarily targets household users, food storage facilities, and supply chain management entities, addressing the global challenges of food safety, wastage, and quality assurance.

B. System components:

The system is made up of a number of interrelated parts, each of which is essential to reaching its goals:

➢ **NodeMCU Microcontroller:**

As the system's central processing unit, the NodeMCU coordinates all system functions. It uses the integrated ESP8266 Wi-Fi module to gather, process, and send sensor data to an IoT platform. It is perfect for Internet of Things applications due to its low power consumption and compatibility with a wide range of sensors.

➢ **Methane Gas Sensor (MQ4):**

Methane, ethanol, and other decomposition gases released during food deterioration are detected by the MQ4 sensor, a crucial component of the system. It allows the system to precisely detect and measure spoiling levels by generating an analog signal proportional to the concentration of gases in the surrounding environment.

➢ **IoT Integration:**

For data logging, processing, and visualization, the system makes use of Internet of Things platforms like Blynk or ThingSpeak. By giving customers access to sensor information in real time, these platforms enable remote food quality monitoring. Mobile applications are used to give warnings and notifications, guaranteeing that users respond quickly.

➢ **LED Indicators and Buzzers:**

For instant on-site notification, both visual and aural alerts—such as buzzers and LEDs—are included. For instance, when rotten gas levels surpass a predetermined threshold, a red LED is activated, giving consumers an easy way to spot problems.

➢ **Power Supply and Connectivity:**

The NodeMCU offers deployment flexibility because it can be powered by external batteries or USB. Real-time data access and monitoring are made possible by the ESP8266 module's Wi-Fi connectivity, which facilitates smooth contact with IoT systems.

C. Working principle:

The suggested Internet of Things (IoT)-based food quality monitoring system works by identifying the gases that are released as perishable goods, such as fruits and vegetables, deteriorate. The system continuously assesses the quality of food items that are stored and sends out real-time alerts and messages when spoiling is detected. It does this by integrating physical components and software.

Sensor Functionality:

The MQ4 methane sensor, which is at the center of the system, is in charge of identifying gases released during food deterioration, including alcohol, methane, and other hydrocarbons. In proportion to the concentration of these gases in the ambient air, the sensor generates an analog signal. As the spoiling process advances, the output values rise, offering a trustworthy indicator of food quality.

Detection Threshold: A preset gas concentration threshold (for example, 250 ppm for methane) is programmed into the system. Food spoiling has begun if the observed gas levels are higher than this cutoff.

Data Acquisition and Processing:

Data Collection: The MQ4 sensor creates analog signals that correspond to the gas concentration levels by continually sampling the air surrounding food products that are being stored.

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Data Conversion: NodeMCU microcontroller, which has an integrated Analog-to-Digital Converter (ADC), receives the sensor's analog output. Analog signals are converted into digital values by the ADC for further processing.

Processing: The digital readings are compared to the preset thresholds that are programmed into the firmware of the NodeMCU microcontroller. The system starts a sequence of steps to notify the user if the detected gas concentration rises over the threshold, guaranteeing prompt actions to handle or dispose of bad food.

Through early spoiling identification, this streamlined procedure guarantees accurate detection, improves food safety, and lowers waste.

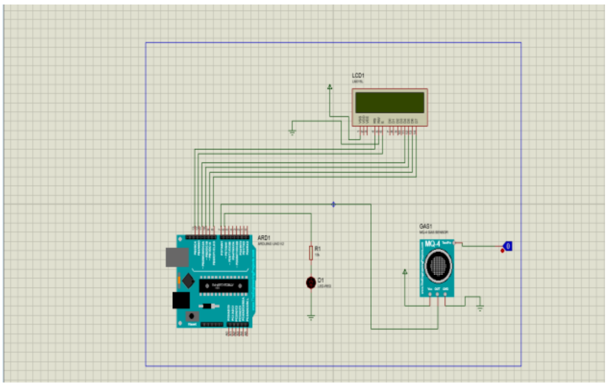

Fig 2: Circuit diagram

D. System Workflow:

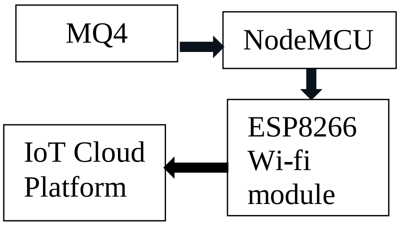

Fig 3. System workflow

Beginning: The ESP8266 Wi-Fi module is used by the NodeMCU to connect to the IoT cloud and initialize the sensors.

Constant Observation: The gas concentration levels in the storage compartment are continuously measured by the MQ4 sensor.

Identifying Spoilage: The technology detects the beginning of spoiling when the gas levels surpass threshold. Alerts are activated immediately on-site.
Transmission of Data.

Data transmission: The cloud platform receives sensor data for logging, processing, and display.

Notification of users: The user is kept informed in real time by the warnings and notifications generated by the IoT platform.

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E. Practical example of Functionality:

Fresh Food: The MQ4 sensor detects very low gas concentrations, usually less than 250 ppm, when fruits are fresh. Good quality is shown by the green LED remaining on.

Food that is rotting: Gas concentrations increase as food begins to decompose.
A red LED, a siren, and an IoT platform warning "Food Spoiled" are all activated by the system when the concentration above 250 ppm.

User Behaviour: To avoid foodborne infections, the user can either eat the food that is about to spoil or throw it out after getting the alert.

IV. CONCLUSION

In order to guarantee food safety and minimize waste, the suggested Internet of Things-based food quality monitoring system effectively identifies rotting gasses and sends out timely alarms. It provides a dependable and effective way to keep an eye on the freshness of food in homes and storage facilities.

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