ABSTRACT

The Internet of Things (IoT)-Based Food Quality Monitoring System aims to revolutionize the monitoring and maintenance of food safety during storage and transportation. The system integrates sensors such as the MQ5 for gas detection and the DHT11 for temperature and humidity measurement, ensuring real-time monitoring of food storage conditions. The data collected by these sensors is processed using a NodeMCU (ESP8266) microcontroller and displayed locally on an LCD for immediate analysis. Additionally, the system uploads the data to the Thingspeak platform, enabling remote monitoring and visualization.

By detecting critical environmental factors such as gas emissions, temperature, and humidity, the system provides early warnings about potential spoilage or contamination, enhancing food safety. This approach offers a cost-effective and scalable solution for industries like food storage, logistics, and retail. The project demonstrates the potential of IoT technology to improve quality assurance processes, reduce food wastage, and contribute to public health and sustainability.

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Chapter 1

Introduction

Ensuring food quality and safety has become a critical challenge in today's world, especially with the increasing complexity of food supply chains. Poor storage conditions, temperature fluctuations, and contamination can lead to spoilage, significant economic losses, and health risks. The Internet of Things (IoT)-Based Food Quality Monitoring System addresses these challenges by providing a reliable, real-time solution to monitor and maintain the quality of food during storage and transportation. This system leverages advanced sensor technology to measure key environmental parameters such as temperature, humidity, and gas levels.

The system employs a NodeMCU (ESP8266) microcontroller as its core, interfacing with sensors like the DHT11 for temperature and humidity monitoring and the MQ5 for detecting harmful gas emissions. The collected data is displayed on an LCD for immediate feedback and uploaded to the Thingspeak platform for remote visualization and analysis. This dual-layered approach ensures both local and cloud-based access to real-time information, allowing users to identify potential spoilage conditions early and take corrective actions promptly.

By integrating IoT technology into food quality monitoring, the project demonstrates a cost-effective, scalable, and efficient solution for industries such as food storage, logistics, and retail. The system not only enhances food safety but also reduces waste, contributing to sustainable practices. This introduction of smart monitoring ensures greater transparency and reliability, addressing a pressing need for innovation in food supply chain management.

Chapter 2

Literature Survey

SI.NO	Authors	Title of Paper	Methodology	Limitations
1.	Gupta, P. R., & Choudhury, V. R. (2020)	"IoT-Based Food Safety System for Transportation"	Describes an IoT solution that monitors environmental conditions during food transportation using GPS and environmental sensors.	May face challenges with data transmission in areas with poor cellular coverage.
2.	Lee, T. J., Kim, H. S., & Park, Y. J. (2021)	"IoT-Based Food Inventory Management System"	Developed an IoT system for tracking food inventory in commercial kitchens using RFID tags and IoT connectivity. Provides real-time updates on stock levels and expiration dates	RFID technology can be costly and may not be suitable for all food items. Requires staff training to effectively use the system, which can be a barrier to implementation.

Chapter 3

Objectives and Problem Statement

OBJECTIVES

- The primary objectives of the IoT Based Food Quality Monitoring System project are as follows:

- Real-Time Monitoring: To continuously monitor critical environmental parameters such as temperature, humidity, and gas levels in food storage and transportation environments.
- Data Display: To provide a user-friendly interface by displaying real-time sensor data on an LCD for immediate on-site analysis.
- Cloud Integration: To upload sensor data to the Thingspeak platform, enabling remote monitoring, data visualization, and trend analysis.
- Early Spoilage Detection: To detect and alert users about unfavorable conditions that could lead to food spoilage or contamination.
- Cost-Effective Solution: To design an affordable and scalable IoT-based system that can be implemented across various food industries, including storage, logistics, and retail.
- Reduce Food Wastage: To minimize food wastage by providing timely information that allows for corrective actions to preserve food quality
- Promote Sustainability: To contribute to sustainable food management practices by improving safety standards and reducing economic losses associated with spoilage.

PROBLEM STATEMENT

The IoT-Based Food Quality Monitoring System solves the critical issue of food spoilage and wastage by providing real-time monitoring of environmental conditions such as temperature, humidity, and gas levels during storage and transportation. Traditional monitoring methods are often inefficient, prone to human error, and lack real-time alerts, leading to undetected spoilage and significant losses. By integrating sensors like the DHT11 and MQ5 with a NodeMCU (ESP8266), the system ensures accurate data collection, displays the information on an LCD for immediate feedback, and uploads it to the Thingspeak platform for remote monitoring. This enables timely detection of unfavorable conditions, allowing corrective actions to be taken, thereby ensuring food quality, reducing wastage, and promoting sustainability in the food supply chain.

Chapter 4

Proposed Methodology

The proposed methodology for the IoT-Based Food Quality Monitoring System involves designing a system that integrates sensors, a microcontroller, and IoT technology to monitor and ensure food safety. The DHT11 sensor is used to measure temperature and humidity, while the MQ5 sensor detects harmful gas emissions. These sensors are interfaced with a NodeMCU (ESP8266) microcontroller, which collects and processes the data. The processed data is displayed on an LCD for real-time local monitoring and uploaded to the Thingspeak platform for remote visualization and analysis. Threshold values are set for each parameter to detect unfavorable conditions, triggering alerts to notify users of potential spoilage risks. The system undergoes rigorous testing and calibration in controlled environments to ensure accuracy before deployment in real-world food storage or transportation scenarios. This methodology provides an efficient, scalable, and user-friendly approach to food quality monitoring, addressing critical challenges in the supply chain.

Block diagram :

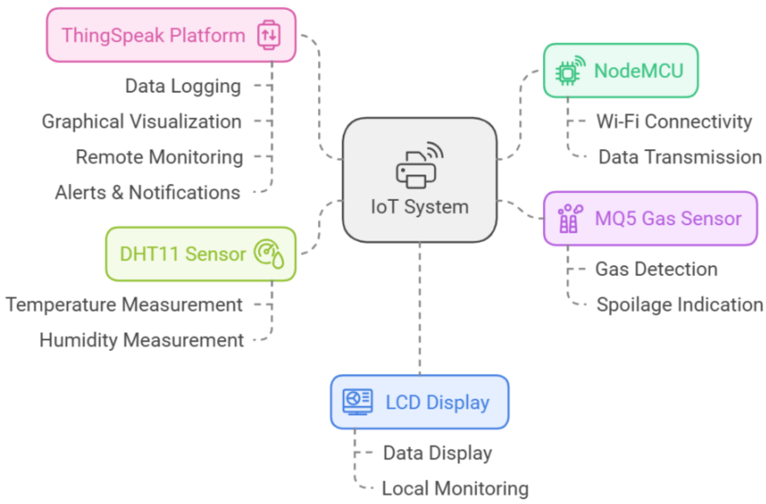

Figure 4.1 Block Diagram

Chapter 5

Hardware and Software Details

Hardware:-

1. NodeMCU ESP8266: Acts as the central control unit for processing sensor data and enabling Wi-Fi communication.
2. MQ5 Gas Sensor: Monitors harmful gases like LPG or methane that may indicate food spoilage or contamination.
3. DHT11 Sensor**:** Measures temperature and humidity to assess the environmental conditions affecting food storage.
4. LCD Display**:** Shows real-time sensor readings locally for user convenience.

Software:-

1. Embedded C++ for Programming the ESP.
2. IoT Integration**:** ThingSpeak provides a user-friendly dashboard for tracking trends, setting alerts, and remotely monitoring food storage conditions

CircuitDiagram :

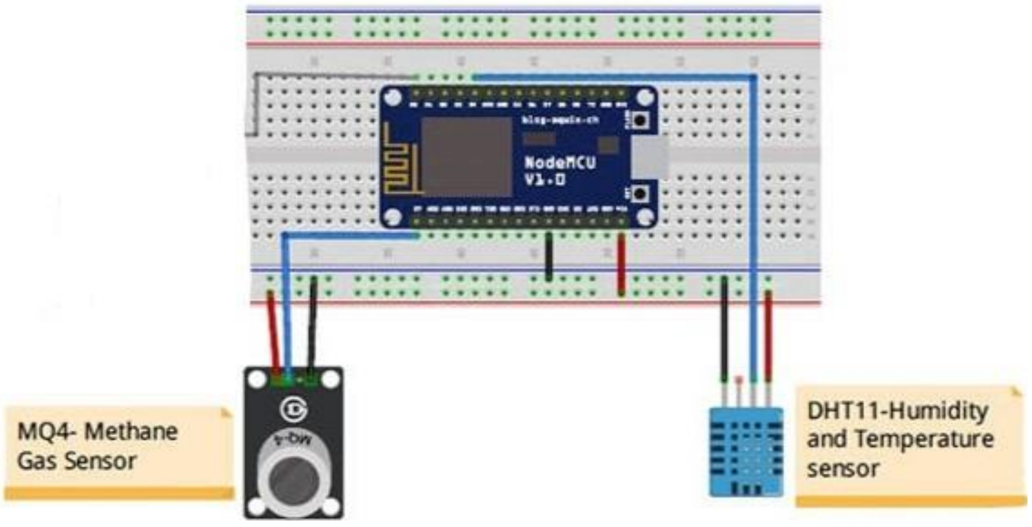

Figure 5.1 Circuit Diagram

Program :

```
#include <DHT.h>
#include <Wire.h>
#include <LiquidCrystal_I2C.h>
#include <ESP8266WiFi.h>
#include <ThingSpeak.h>

#define Gas_Pin A0
#define DHTPIN D4 // Connect the DHT11 sensor to pin D4 of the NodeMCU

const char *myWriteAPIKey = "Your_Thingspeak_API_Key";
unsigned long myChannelNumber = Your_channel ID; // Replace with your channel ID
const char *ssid = "Your_SSID";
const char *password = "Your_PASSWORD";

DHT dht(DHTPIN, DHT11);
WiFiClient client;
LiquidCrystal_I2C lcd(0x27, 16, 2); // Initialize the LCD with I2C address 0x27

void setup() {
  Serial.begin(9600);
  dht.begin();
  lcd.init();
  lcd.backlight();
  ThingSpeak.begin(client);

  WiFi.begin(ssid, password);
  Serial.println();
  Serial.println("Connecting to WiFi");
  lcd.setCursor(0, 0);
  lcd.print("Connecting WiFi");

  while (WiFi.status() != WL_CONNECTED) {
    delay(200);
    Serial.print(".");
  }

  Serial.println("\nWiFi connected");
  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("WiFi Connected");
}

int readGasValue() {
  int sensorValue = analogRead(Gas_Pin); // Read analog value directly from the sensor
  return sensorValue;
}

void loop() {
  float t = dht.readTemperature();
  float h = dht.readHumidity();
  int gas = readGasValue();

  if (isnan(t) || isnan(h) || isnan(gas)) {
    Serial.println("Failed to read from sensors!");
    lcd.setCursor(0, 0);
    lcd.print("Sensor Error");
    return;
  }

  Serial.print("Temp: ");
```

```
  Serial.print(t);
  Serial.println(" C");

  Serial.print("Humidity: ");
  Serial.print(h);
  Serial.println(" %");

  Serial.print("Gas Value: ");
  Serial.println(gas);

  // Determine food status based on gas value thresholds
  String status;
  if (gas < 70) {
    status = "Good";
  } else if (gas > 70 && gas <= 100) {
    status = "Rotten";
  } else {
    status = "Severely Rotten";
  }

  Serial.print("Food Status: ");
  Serial.println(status);

  // Display temperature and humidity
  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("Temp:");
  lcd.print(t);
  lcd.print("C");

  lcd.setCursor(0, 1);
  lcd.print("Humidity:");
  lcd.print(h);
  lcd.print("%");
  delay(3000); // Wait for 3 seconds

  // Display gas level and food status
  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("Gas:");
  lcd.print(gas);

  lcd.setCursor(0, 1);
  lcd.print("Status:");
  lcd.print(status);
  delay(3000); // Wait for 3 seconds

  ThingSpeak.writeField(myChannelNumber, 1, t, myWriteAPIKey);
  ThingSpeak.writeField(myChannelNumber, 2, h, myWriteAPIKey);
  ThingSpeak.writeField(myChannelNumber, 3, gas, myWriteAPIKey);

  delay(2000);
}
```

Chapter 6

Results and Discussion

Result:

The IoT-Based Food Quality Monitoring System effectively monitors and transmits key environmental parameters, such as gas levels, temperature, and humidity, ensuring safe food storage conditions. The MQ5 sensor reliably detects gas concentrations, indicating spoilage risks, while the DHT11 sensor provides accurate temperature and humidity readings to assess storage environments. The integration with ThingSpeak enables real-time remote monitoring and data visualization, offering users convenient access to trends and storage conditions. The system performed reliably during testing, providing consistent and accurate readings, and the local LCD display further enhances usability by displaying real-time data. While the project demonstrates practical utility in food safety and waste reduction, future enhancements such as sensor calibration for specific food types or predictive analytics could improve its effectiveness. Overall, the system highlights the potential of IoT in revolutionizing food quality management.

Snapshot of the model:

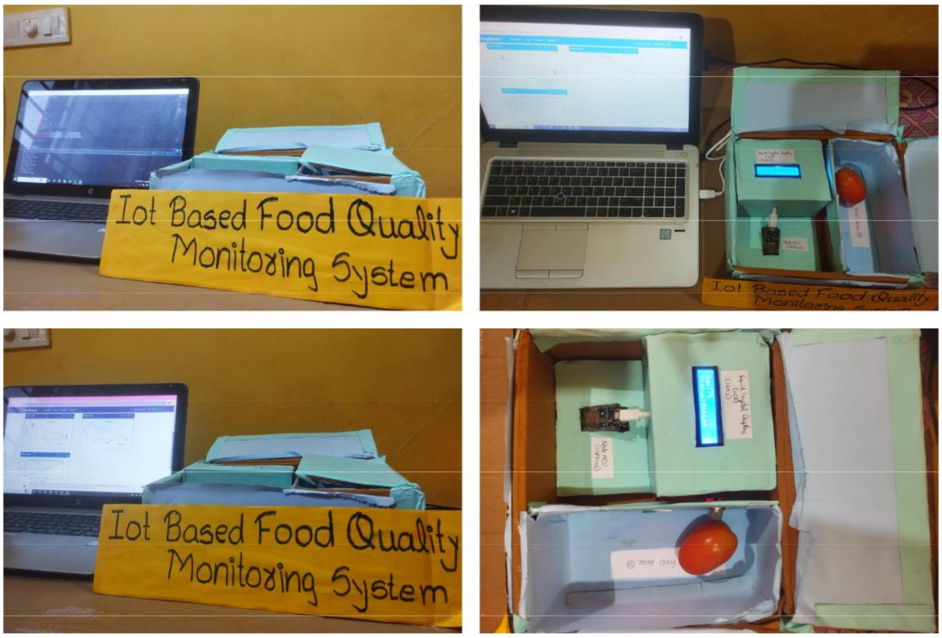

Figure 6.1 Snap shot of Working Model

Chapter 7

Advantages and Applications

Advantages :

- Provides real-time monitoring of food quality parameters like gas levels, temperature, and humidity.
- Enables remote access and visualization through ThingSpeak for convenient monitoring.
- Cost-effective solution using affordable IoT components like NodeMCU, MQ5, and DHT11 sensors.
- Helps in early detection of spoilage, reducing food waste and ensuring safety.
- User-friendly with a local LCD display for instant data visibility.

Applications :

- The IoT Based Food Quality Monitoring System can be applied in various scenarios, including:
- Household Food Storage**:** Monitors temperature, humidity, and gas levels in refrigerators or pantries to prevent food spoilage and ensure quality.
- Restaurants and Commercial Kitchens**:** Ensures optimal storage conditions in food preparation and storage areas, reducing waste and maintaining hygiene.
- Cold Storage Facilities**:** Tracks environmental parameters in large-scale storage facilities to maintain the quality of perishable goods.
- Food Transportation and Supply Chains**:** Monitors food quality during transportation to ensure conditions are maintained throughout delivery.
- Supermarkets and Grocery Stores**:** Helps maintain the freshness of stored food products by monitoring storage conditions in display and storage units.

Chapter 8

Conclusion and Future Scope

The IoT-Based Food Quality Monitoring System effectively demonstrates the potential of IoT technology in ensuring food safety and reducing spoilage. By integrating sensors like MQ5 and DHT11 with NodeMCU and ThingSpeak, the system provides real-time monitoring of gas levels, temperature, and humidity, which are critical for maintaining food quality. The ability to remotely monitor and visualize data on a cloud platform ensures user convenience and timely action in case of adverse conditions. The project highlights a cost-effective and user-friendly solution to address the challenges of food quality management, making it suitable for household and commercial applications.

The future scope of the IoT-Based Food Quality Monitoring System is promising, with several opportunities for enhancement and expansion. Future developments could include the integration of additional sensors to monitor other quality parameters, such as pH levels or microbial contamination, thereby providing a more comprehensive assessment of food safety. Furthermore, implementing machine learning algorithms could enable predictive analytics, allowing for proactive measures to be taken before quality degradation occurs. Additionally, expanding the system's connectivity to include mobile applications or cloud-based platforms could facilitate real-time alerts and remote monitoring, making it more user-friendly and accessible. As the demand for food safety and quality assurance continues to grow, this project can evolve to meet emerging challenges and contribute to smarter food supply chains.

Chapter 9

References

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