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Food Spoilage Detection System Using Arduino Uno

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Abstract: *This project focuses on designing an Arduino Uno-based air quality and methane detection system aimed at monitoring environmental conditions to prevent food spoilage and detect hazardous gas leaks. The system integrates multiple sensors, including the DHT11 for temperature and humidity monitoring, MQ135 for air quality assessment, and MQ04 for methane detection, providing real-time data on environmental parameters that contribute to food degradation and potential safety hazards. The collected data is displayed on an I2C LCD, offering a user-friendly interface to visualize temperature, humidity, air quality, and methane levels. To ensure timely alerts, the system incorporates a buzzer that activates when predefined thresholds are exceeded, indicating spoilage conditions (such as high humidity and temperature) or dangerous methane concentrations, thereby enabling prompt corrective actions. Power is supplied via two Li-ion cells, ensuring portability and efficient energy usage. By combining sensor data with an intuitive alert mechanism, this project provides a cost-effective and reliable solution for both household and industrial applications, enhancing food safety and mitigating risks associated with methane exposure. The system's modular design allows for future expansions, such as IoT integration for remote monitoring, making it a versatile tool for environmental and safety monitoring.*

Keywords: MQ-4sensor,DHT11sensor,BuckConverter, MQ135

I. INTRODUCTION

The food spoilage detection system leverages Arduino technology to monitor and alert users about the freshness of their food items effectively. This innovative approach utilizes various sensors to continuously assess food quality, ensuring timely notifications to prevent spoilage and waste. This system not only enhances food safety but also contributes to reducing food waste, a significant concern in today's society. This technology aligns with the growing need for efficient solutions to everyday challenges and supports the broader goal of sustainable consumption and production. This system exemplifies how technological advancements can be integrated into daily life to promote sustainability and efficiency in food management. This integration of Arduino technology with sensor systems represents a significant step toward minimizing food waste and enhancing food safety in households.

Food spoilage is a critical issue that affects both consumer health and environmental sustainability. Implementing effective monitoring systems can significantly reduce the risks associated with spoiled food. The integration of IoT sensors and machine learning algorithms can further enhance the effectiveness of food spoilage detection systems by providing real-time monitoring and predictive analysis. This proactive approach not only helps in preventing spoilage but also promotes sustainability throughout the food supply chain.The adoption of such technologies not only aids in preserving food quality but also supports a more sustainable food supply chain by minimizing waste and optimizing resource use. This proactive strategy is essential for addressing the pressing issue of food waste, which is a significant global challenge affecting both environmental sustainability and food security.

Food safety is paramount, as it directly impacts public health and the overall integrity of the food supply chain, necessitating the implementation of advanced monitoring systems for effective management. The integration of advanced monitoring systems, such as IoT-based solutions, is crucial for ensuring food safety and minimizing spoilage risks throughout the food supply chain to effectively manage food safety challenges and enhance consumer trust in food products.Implementing such systems not only addresses food safety concerns but also aligns with the increasing demand for transparency and accountability in food management practices.

II. ROLE OF TECHNOLOGY IN FOOD PRESERVATION

The use of technology, particularly IoT and Arduino systems, plays a vital role in enhancing food preservation methods by providing real-time monitoring and alerts for potential spoilage risks .and ensuring that food quality is maintained throughout the supply chain. By utilizing sensors to track critical parameters, stakeholders can make informed decisions to prevent spoilage and enhance food safety This integration of technology not only optimizes food preservation but also fosters a culture of sustainability by reducing waste and improving resource efficiency throughout the food supply chain.This approach demonstrates the potential of innovative technologies to create a more resilient and sustainable food system, addressing both food safety and environmental concerns effectively.

The continuous development and application of these technologies are essential for establishing a more efficient and transparent food safety management system, ultimately benefiting public health and environmental sustainability.

III. LITERATURE SURVEY

IOT based food spoilage detection system using Arduino UNO, B. Mounica , CH Gayathri devi, K.Vishnuvardhan, I. Anil kumar, Dr.Chinmayakumarpradhan. International journal of engineering technology and management sciences. 6th july2022,This paper talks about a smart system that helps detect when food is going bad, using an Arduino and some sensors. The system checks the air around the food for gases like methane and ammonia, which come out when food starts to spoil. It also checks the temperature and humidity using a sensor called DHT11. All the information is read by the Arduino and shown on a small display screen. The system also sends a message to the user's phone using Wi-Fi. It is cheap, uses little power, and can warn users before the food looks spoiled. This helps people know if their food is safe to eat, especially in fridges. The system worked well in tests and can help avoid health problems and reduce food waste.

A comprehensive Approach to food spoilage detection in refrigerators: A comparative study on methodologies and implementation, Vishal G.Jamdhade, Pratibha shingare, 2024 4th Asian conference on innovation in pune, india, Aug 23-25 2024. This research paper compares different methods to detect spoiled food in refrigerators. It focuses on the problem of food waste, especially in India, which wastes about 68.7 million tonnes of food each year. The study looked at methods like gas sensing, image processing, and chemical tests. They used a Pugh matrix to compare 14 factors such as cost, accuracy, and ease of use. Gas sensing with Metal Oxide Semiconductor (MOS) sensors was found to be the best and cheapest method. Methane was the main gas released when food spoiled. The researchers tested a system with a MOS gas sensor and Arduino in a fridge. It could detect spoiled food by noticing gas level changes. This system worked well in real-time. It can help create smart fridges that reduce food waste.

IV. METHODOLOGY

The methodology of this project revolves around the systematic integration of hardware components, sensor calibration, Arduino programming, and real-time data processing to achieve an efficient air quality and methane detection system. The Arduino Uno serves as the central processing unit, interfacing with multiple sensors—DHT11 (temperature and humidity), MQ-135 (air quality), and MQ- 4 (methane detection)—to collect environmental data continuously.

The DHT11 sensor provides digital output for temperature and humidity, ensuring accurate readings with minimal noise interference, while the MQ-135 sensor, calibrated to detect harmful gases such as ammonia, benzene, and carbon dioxide, employs a chemical-sensitive layer that changes resistance in the presence of pollutants, with the Arduino converting this analog signal into a readable concentration value (ppm) through voltage division and pre- loaded calibration curves. Similarly, the MQ-4 methane sensor operates on the principle of electrochemical detection, where methane gas interacts with a tin dioxide (SnO_2) sensing layer, altering its conductivity proportionally to gas concentration, and the Arduino processes this analog signal using a predefined sensitivity adjustment resistor (RL) and a voltagedivider network to output methane levels in ppm.

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The I2C LCD module displays real-time sensor data, reducing wiring complexity by utilizing a serial communication protocol (I2C) that requires only four connections (VCC, GND,SDA, SCL) to the Arduino, enhancing system reliability. A buzzer is incorporated as an auditory alert mechanism, programmed to activate whensensorreadingsexceedpredefinedthresholds(e.g.,methanelevels>1000 ppm or temperature > 30°C with humidity > 70%, indicating potential food spoilage or hazardous gas accumulation), ensuring immediate user notification.

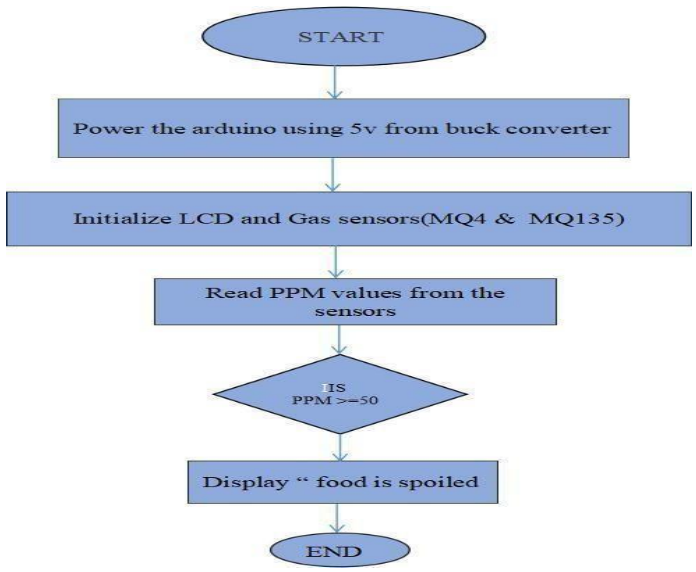

Fig. 1Flow chart of Food spoilage detection system

Power is supplied via two Li-ion cells connected in series (7.4V nominal), regulated to 5V using a DC- DC buck converter to ensure stable operation of the Arduino and sensors while optimizing battery life.

The software framework is developed in the Arduino IDE, employing a loop-based structure where sensor data is sampled at fixed intervals (e.g., every 2 seconds) to prevent sensor drift and ensure consistent accuracy. The code initializes serial communication for debugging, configures sensor pins (analog for MQ sensors, digital for DHT11), and implements conditional statements to comparereadings against safety thresholds—triggering the buzzer and displaying warning messages on the LCD when anomalies are detected. To enhance system robustness, software debouncing is applied to eliminate false triggers from sensor noise, and averaging filters smooth analog readings over multiple samples.

Calibration of the MQ sensors involves exposing them to known gas concentrations and adjusting theR0 (sensor resistance in clean air) value in the code to ensure measurement accuracy, while the DHT11'sbuilt-indigital signal processingminimizescalibration needs.The hardware isassembled ona breadboard (for prototyping) or a custom PCB (for permanent deployment), with careful attention to minimizing electromagnetic interference (EMI) by separating analog and digital signal paths and using decoupling capacitors near power inputs. Validation involves testing the system in controlled environments (e.g., introducing methane gas near the MQ-4 or simulating spoilage conditions with heat and humidity) to verify sensor responsiveness and alert accuracy. This methodology ensures a reliable, scalable, and cost-effective solution for real-time environmental monitoring, combining sensor fusion, embedded programming, and user-centric alert mechanisms to address safety and food preservation challenges.

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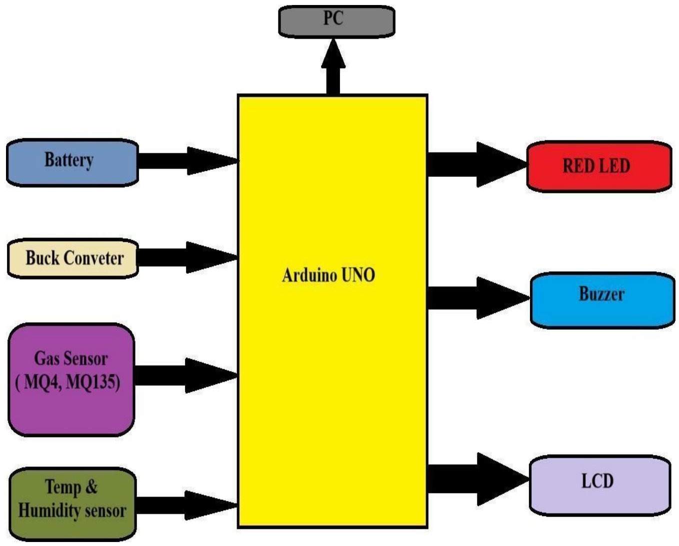

Fig. 2Block Diagram of Food spoilage detection system

ARDUINO UNO

The Arduino Uno represents a type of microcontroller board that utilizes the ATmega328 chip, wit h 'Uno' being an Italian word meaning one. This board is named to signify the forthcoming launch of the Arduino Uno Board 1.0. It features a variety of components including 14 digital I/O pins, a power input jack, 6 analog inputs, a 16 MHz ceramic resonator, a USB interface, a reset button, an d an ICSP header. These features enable the microcontroller to operate effectively when connected to a computer. Powering the board can be achieved through an AC to DC adapter, a USB cable, or a battery. This article elaborates on what an Arduino Uno microcontroller is, its pin layout, specifi cations, and various applications

Battery

This LG INR18650 M26 24600mAh LithiumIon Power Source offers great bang for your buck. Featuring a nominal voltage of 3.7 volts and a capacity of 2600mAh, it is a compact and robust single cell battery with a capacity of 2600 mAh. It's ease of installation makes it ideal for your project to meet the high capacity 3.7 Volt requirement

DHT11 - Temperature and Humidity Sensor Module

The DHT11 sensor is a low-cost, reliable digital sensor designed to measure both temperature and humidity in the environment. It is widely used in embedded systems and IoT projects due to its ease of use, accuracy, and availability.The DHT11 sensor consists of two main components: a capacitive humidity sensor and a thermistor for temperature measurement. The capacitive humidity sensor measures the relative humidity by detecting changes in electrical capacitance caused by moisture in the air. Meanwhile, the thermistor measures the ambient temperature by varying its resistance with temperature changes. Below shows DHT11 temperature & humidity sensor

MQ 135 Air Quality/Gas Detector Sensor Module

The MQ135 sensor functions based on the principle of a tin dioxide (SnO_2) semiconductor whose electrical resistance varies according to the levels of target gases present in the surroundings. Upon activation, its internal heating component warms the SnO_2 surface to a predetermined temperature. This heated surf ace undergoes a chemical reaction with gases like ammonia or benzene present in the air. As gas molecules interact with the SnO_2 surface, they either donate or remove electrons, altering the sensor's resistance. The Arduino reads this change as an analog voltage signal, which correlates to the gas concentration.

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MQ 4 Sensor

The MQ4 acts as a semiconductor gas detector. It comprises a heating element and a sensing sub strate (usually tin dioxide, SnO_2). In pure air, the sensing substrate exhibits a specific resistance. When a target gas is detected, it adheres to the sensor's surface, initiating a chemical reaction th at alters the resistance of the sensing substrate. This alteration in resistance is directly related to the level of the gas present.

Buck Converter

A buck Converter also known as a step-down DC-DC converter, is an essential power supply component used to reduce a higher voltage to a lower, stable voltage required by electronic components. In embedded systems like the Food Spoilage Detection System, it is particularly important when powering the setup with a battery pack or external supply that exceeds the voltage tolerance of the Arduino UNO and sensors

I2C module

The primary motivation for using an I2C module with an LCD is to minimize the number of GPIO (General Purpose Input/Output) pins required on the microcontroller. Standard character LCDs (like 16x2 or 20x4) typically need at least 6 control/data pins for basic operation. In more complex setups involving multiple sensors and actuators, these pin requirements can quickly become a limiting factor. The I2C module acts as a bridge, translating the serial I2C commands from the microcontroller into the parallel data signals that the LCD understands. This allows control of the LCD using just two data lines (SDA - Serial Data, SCL - Serial Clock), along with power (VCC) and ground (GND).

V. RESULTS

The Food Spoilage Detection System is tested for different types of fruits like Mangoes, Banana, Apple Orange the ripening concentration and spoilage concentration is listed in Table1

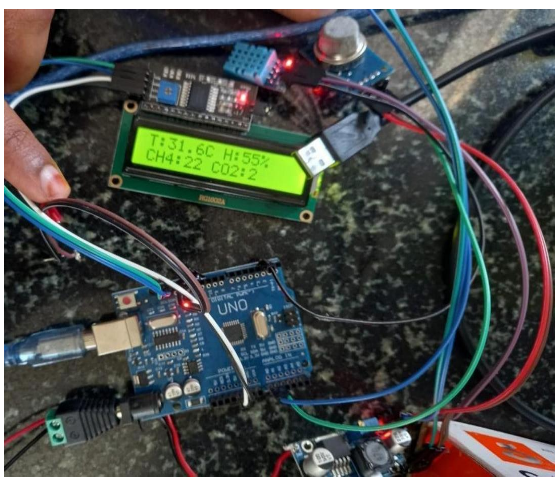

Fig. 3Shows the model of food detector with LCD display

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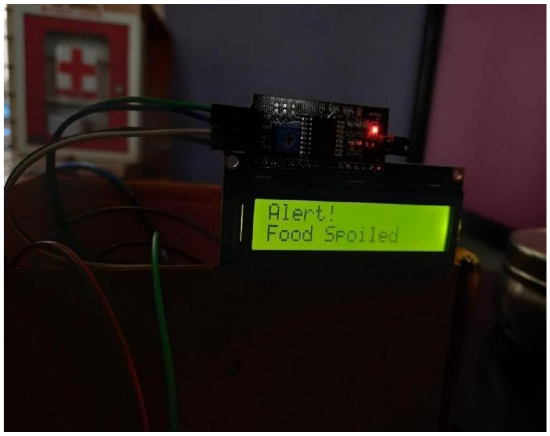

Fig. 4 shows the result of Food spoilage

TABLE I: FRUITS

Fruit	Indicator	Ripening Concentration (ppm)	Spoilage concentration (ppm)
Mangoes	Ethylene	N/A	20-50
Bananas	Ethylene	10-30	50-100
Apple	Ethylene	10-50	100-200
Oranges	VOCs	N/A	20-50

TABLE III: VEGETABLES

Vegetable	Indicator	Ripening Concentration (ppm)	Spoilage Concentration (ppm)
Tomato	VOC	N/A	40-50
Cabbage	VOC	N/A	150-200

TABLE III : FOOD

Food	Indicator	Ripening Concentration (ppm)	Spoilage Concentration (ppm)
Rice	VOC	N/A	40-50
Salad	VOC	N/A	50-70

The implementation of this project also highlights the importance of preventive food safety measures and shows how modern embedded technologies can significantly reduce food waste, improve food quality, and contribute to better public health outcomes.

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