`Food quality detection and monitoring system using smart technology

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Abstract : The increasing reliance on smart devices has led to a surge in efforts to solve everyday problems more efficiently and conveniently. Smart technology has made it easier to control various tasks in industries and homes. This paper focuses on developing a food quality detection and monitoring system using Arduino. The proposed system utilizes a detection and recognition algorithm to identify and report food spoilage, aiming to automate the process of detecting spoiled food and alerting users. Arduino, a microcontroller-based technology, plays a crucial role in this system. The paper discusses the programs and sensors used in Arduino, highlighting its importance in computer vision applications due to its marketability and compliance with legal standards. Recent advancements have made realistic technology more accessible, sparking interest among researchers and scientists from diverse fields, including computer science, food science, and various organizations. Microcontrollers, like Arduino, can interpret inputs and outputs, triggering sensors based on this data. While refrigeration slows bacterial growth, certain perishable foods require timely detection and notification. This system addresses food spoilage by continuously sensing food signals and sending alerts to an LCD display.

Introduction:

Food plays a vital role in human life; hence having healthy food is of utmost importance for several reasons. Food safety and hygiene plays important role in country's economy. It is a major concern in order to prevent the food wastage. The food we consume can affect in any form of contamination that may occur due to storage or chemical changes within the food. There are several viruses and bacteria that cause food contamination and leads to numerous food borne diseases. About 351,000 people die of food poisoning globally every year. In some countries, majority of people struggles on daily basis for food, due to preservation of foods and use of chemicals to artificially increase the time span of food causes people illness. It is necessary to develop a system that can help people to identify the freshness of food or quality of food items. Our proposed system may give the good quality (freshness)

management in food [1]. This project is mainly required to detect the food spoilage. It mainly works through sensors like MQ3, temperature and humidity etc. This sensors continuously sense the food materials to detect whether the food material is spoiled or not. This sensors send the data to Arduino which analyzes the data according to the code written in it. After analyzing the data it displays the readings of food material through LCD and alerts the person about the quality of the food material. However, different types of foods emit different types of gases when at the merge of getting spoilt. Further research is needed to be done in this context and the sensors are needed to be used accordingly. O Farrell and his collaborator [2] presents an approach that uses machine learning to monitor food quality with the help of a polarization image sensor. This sensor can capture images of food products and use machine learning algorithms to detect any changes in their quality. Similarly Rohan Wagle and his group [3] presents a food standard (quality) monitoring system that uses an Arduino microcontroller to collect data from various sensors. The system can track humidity, temperature and gas levels in food storage environments. Bin Yu and Ping Zhan [4] presents e-Fresh, advice that can detect food freshness. The device uses gas sensors to detect the presence of specific gases that are produced as food begins to spoil. P.A. Lovina & G. Shiva Kumari [5] study the monitoring and control systems that uses IoT technology. Their study covers various systems that have been developed to monitor temperature, humidity, and other environmental factors that affect food quality. Also Robin Raju, Greg E. Bridges & Sharmistha Bhadra [6] presents an efficient food storage system that uses sensors, Android, and IoT technology. The system is capable of monitoring the moisture and temperature levels of the environment where food is stored, and alert users if there are any deviations from the desired levels. Similarly different reports have been found in the literature related to monitoring and quality control system for food detection process [7-10]. It is very important to develop a system which helps the society to identify the freshness of food. Good quality management system of food is based on electrical, and biosensors [11]. Md. Johirul Islam Tutul and his group works on smart food monitoring system based on IoT and machine learning [12]. Pradana, Djatna and Hermadi works on modeling for traceability information system in the supply chain of coffee [13]. Thus different reports are found to be reported in different period of time for continuous development of the food control management system [14-17]. In the year 2022, H. Alkahtani and T. H. Aldhyani developed a cyber security systems based on machine learning and deep learning algorithms for protecting food security systems [18]. H. Kaur works on internet modeling of driven sustainable food security system [19]. Recently P Wisudawaty and his group analyze and design a smart food packaging

monitoring model based on chipless RFID sensor in the year 2024 [20]. Thus keeping in view of advantages of smart food control system, in this work we have carried out an approach which is helpful for the society for monitoring and controlling the food spoilage detection system with better accuracy by using sensors.

Motivation of the work:

The detection of food spoilage is driven by a range of critical concerns, including food safety, quality control, economic sustainability, regulatory adherence, environmental sustainability, and supply chain optimization. Implementing robust detection systems enables businesses to minimize the risks associated with food spoilage, safeguard consumer well-being, and maintain the integrity of the food supply chain. Moreover, utilizing food spoilage detection systems streamlines monitoring and analysis, saving time while providing accurate and consistent results**.**

Objective of the work:

a) Design a smart food quality monitoring system utilizing temperature, humidity, and gas sensing mechanisms to track food freshness.

b) Develop an alert generation system that notifies users about food quality and deterioration timelines, ensuring timely consumption or disposal.

c) Create a system that optimizes food storage conditions, maintaining an ideal environment to extend shelf life and reduce food waste.

Advantage of this work:

a) Extended shelf life: Fruits and vegetables can be stored for longer periods, as the system determines their freshness duration.

b) Enhanced hygiene: The system maintains a clean and hygienic environment, reducing contamination risks.

c) Increased profitability: By minimizing food spoilage and optimizing storage conditions, commercial losses are reduced, and profits are increased.

d) Data-driven insights: Stored data on food products in the cloud enables analysis and informed decision-making, further optimizing food storage and management practices.

Food Spoilage Process:

Food spoilage occurs when a product becomes unfit for consumption due to various external factors, including the type of food, packaging, and processing methods. Unfortunately, a significant amount of food produced globally is lost annually, with approximately one-third of the world's food supply intended for human consumption being wasted. As illustrated in Figure 1, the spoilage process can be rapid, as seen in the case of fresh apples. Once microorganisms like bacteria, viruses, protozoa, and fungi begin to break down the apple, gas emissions occur, and the fruit can become completely spoiled within hours. These microorganisms can produce harmful toxins, posing serious health risks to consumers.

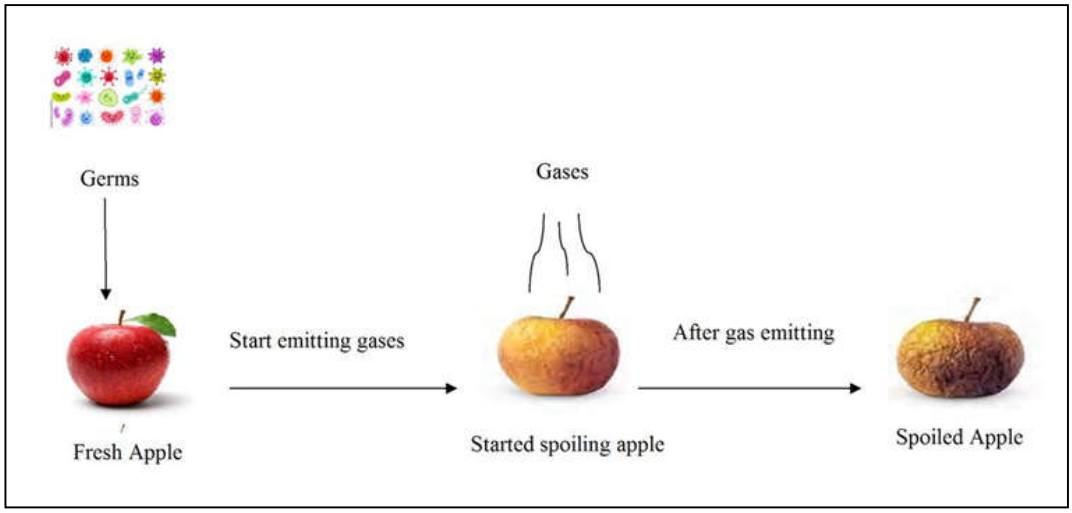


Figure 1: Food spoilage process

Here' some overview of the food spoilage processes:

Microbial growth:

Microorganisms such as bacteria, yeast, and mold can proliferate on food, leading to spoilage. The growth of these microorganisms is influenced by various factors including temperature, moisture, pH and nutrient availability influence microbial growth.

Enzymatic reaction:

Enzymes inherently present in food can trigger biochemical reactions, resulting in spoilage. Examples of enzyme-induced spoilage include browning in fruits and vegetables or breakdown lipids, leading to rancidity in fats and oils.

Chemical reaction:

Chemical reactions can contribute to food spoilage through various mechanisms, including lipid oxidation, resulting in rancidity in fats and oils. Reactions between food components or with external substances, such as metals, leading to undesirable changes in Color, Flavor and texture.

Physical damage:

Color changes: Browning reactions, oxidations and microbial growth can cause discoloration in food products, altering their appearance and visual appeal.

Structural Damage: Physical damage, such as bruising, crushing, or puncturing, can create entry points for microbes and accelerate spoilage processes in fruits, vegetables and meats.

Environmental conditions:

Temperature: Inadequate refrigeration or improper storage temperatures can promote microbial growth and accelerate enzymatic reactions, leading to food spoilage.

Humidity: High humidity levels can create favorable conditions for mold yeast growth, particularly in stored grains, nuts, and dried fruits.

Materials and methods:

Components required : (a) Arduino Uno

Arduino Uno is an open source microcontroller board. It is best on microchip ATmega328P microcontroller. It is developed by Arduino.cc. Ithas20inputoutputpinsin which14hourdigitalimportant coupons 6 analogue input output pins it is programmable by Arduino Integrated Development Environment (IDE) via type-BUSB cable. We can interface various modules like LCD, sensors, Wi-Fi module, Bluetooth etc. It is powered by external 9 volts battery or USB cable. Power supply required by Arduino board in between 7 to 20 volts. The word 'UNO' means 'one' in Italian which is reference version for newer releases. AT

mega 328 is pre-programmed with boot loader which allows new code without external hardware programmer.

A Tmega328 Pare Microcontroller used in ArduinoboardisATmega382P microchip. It operated at 5V.The input voltage required between 7 to 20 volts. It includes Universal Asynchronous Receiver Transmitter (UART), Inter Integrated Circuits (I2C) and Serial Peripheral Interface (SPI). Flash memory is 32 kb in which 0.5kb used for boot loader. SRAM is 2kb, EEPROM is 1 kb. DC current required for one input pin is20 mA and for 3.3V. Pin it required 50 mA. The clock required is 16 MHz.

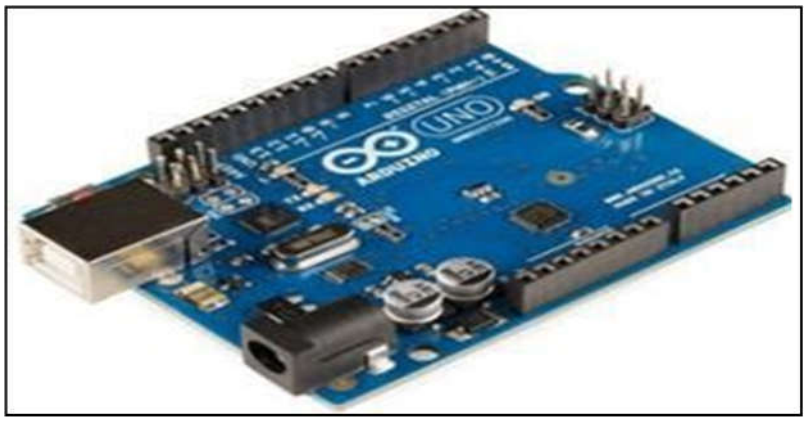


Figure 2 : Arduino Uno

(b) MQ3 Sensor :

MQ standards for having sensitivity towards gas. It is made up of metal oxide semiconductors. MQ sensor are called chemo resistor because sensor values change according to change in resistance of gas. Specifications of MQ3 sensor are it operates 5V dc and draw 800 Mw, sensor resistance from 1M to 8MΩ , load resistance is 200kΩ. This module has 4 pins Analog Output (A0), Digital Output(D0), VCC, GND pins. The A0 pin output will be varied according to concentration of gas ,when concentration of gas is high, output of A0 pin is high and vice versa for low concentration of gas. We can take output at D0 pin. To adjust sensitivity of D0 pin, this module has comparator and potentiometer. According to threshold voltage the output of the D0 pin is low or high. We can set the threshold voltage by varying potentiometer, by rotating clockwise potentiometer will increase sensitivity and anticlockwise decrease its sensitivity.

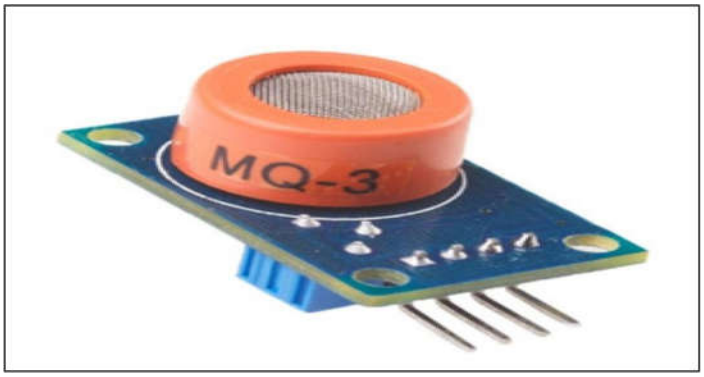


Figure 3 : MQ3 Sensor

(c) DTH11 Sensor :

DTH 11 is a humidity and temperature sensor, which which generates calibrated digital output. DHT11 can be interface with any microcontroller and get instantaneous results. DHT11 is a low cost humidity and temperature sensor which provides high reliability and long term stability.

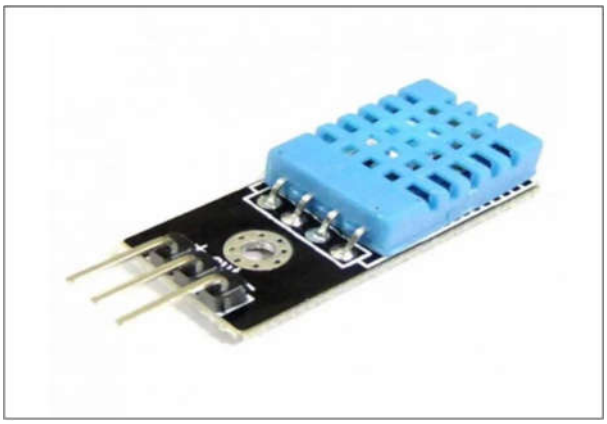


Figure 4 : DTH11 Sensor

(d) LCD Display :

LCD stands for liquid crystal display. It will display characters therefore it is also known as character LCD .16 X 2 indicates 16 characters in each column, 2 indicates 2 rows. each character has a grid of 5 x 8 pixels. It has 16 pins VSS connected to ground, VCC Power supply of LCD is 5V,VEE to set control contrast, Register Select(RS) If this pin is LOW,LCD will send commands depending on cursor location, If RS pin isHIGH, it will send data to LCD. Read/Write (R/W) If this pin is LOW indicates WRITE mode i.e., LCD as output device. If R/W pin is HIGH indicates READ mode. Enable(EN) This will enable the chip if it is HIGH otherwise LCD won't respond to R/W, RS, data pins. Data pins DB0-DB7 Itis8-bitdatabus.MostlyDB4-DB7pinsareused.,LED+connectedto 3.3VofArduinoandLED-Thispinisconnectedtoground.

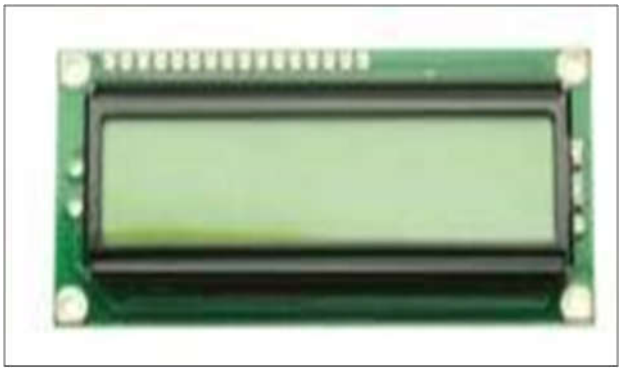


Figure 5 : LCD Display

(e) Breadboard:

A breadboard consists of a plastic block that possesses a matrix of poweroutletsforelectricaldevicesofasizeacceptableforgrippingthin connecting cables, element cables or the legs of transistors and integrated circuits (ICs). The sockets are connected inside the board, generally in rows of five sockets.

Figure 6 : Bread board

(f) Jumper cables :

Jumper cables are cables that have connector legs at each end, allowing them to be used to connect two points without soldering. Jumper cables are generally used with breadboards and other prototyping tools to make it easy to change a circuit as demanded.

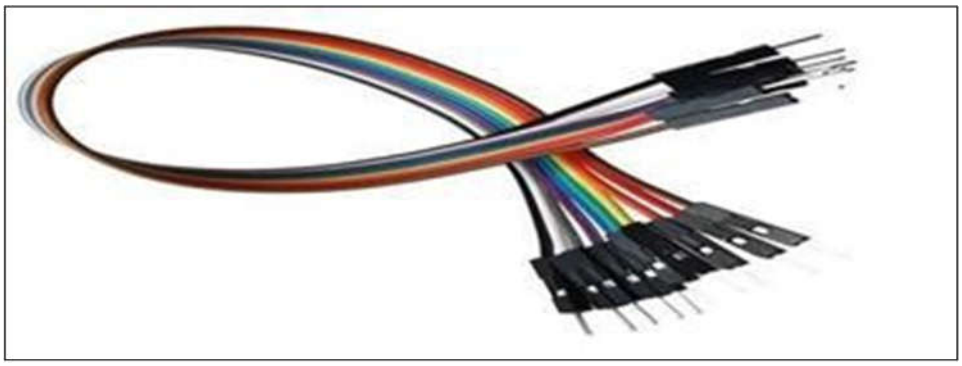


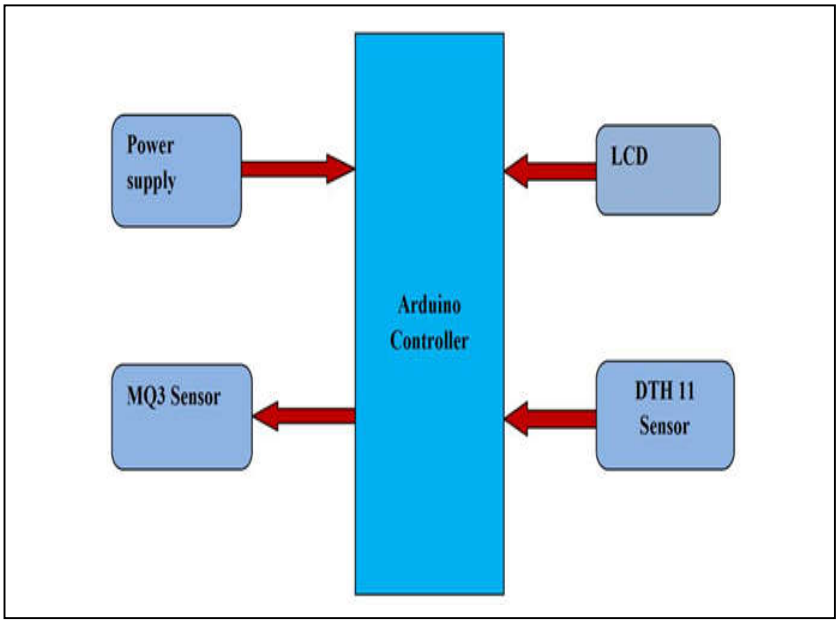
Figure 7: Jumper cables

Methodology:

A food quality detection and monitoring system is designed to track critical environmental parameters such as temperature, humidity, and gas emissions from spoiled food. When food spoils, it releases various gases as byproducts of microbial activity and biochemical reactions. The specific gases emitted depend on the food type, spoilage mechanisms, and microorganisms present. Notably, methane is a hazardous gas released during spoilage.This project utilizes an MQ3 gas sensor to detect methane gas concentrations, even at lower levels. The system's hardware components include Arduino, MQ3 gas sensor, DHT11 sensor, LCD display and Power supply.The DHT11 sensor monitors temperature and humidity in the food storage environment, sending analog data to the Arduino. The Arduino converts this data into digital values, comparing them to predefined threshold values for each food sample. If the values exceed the threshold, the Arduino alerts the LCD display, indicating whether the food

has spoiled. This system enables real-time monitoring of food quality, providing a reliable and efficient method for detecting spoilage.

Block diagram is given below :



Flowchart is given below:

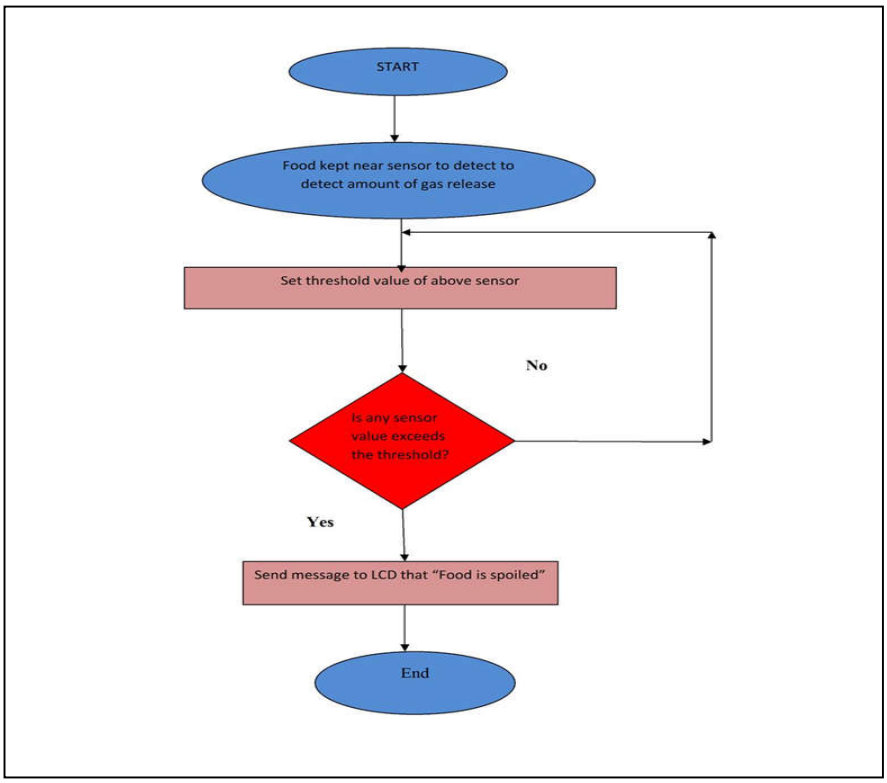


Figure 8: Once the food is kept near the sensor the gases release by the food is monitored and if the gases released by the food exceeds the limit set on the sensors then the message is sent to the LCD that “the food is spoiled “and if the gases released are below the threshold value then the sensors keep on sensing until the threshold value is reached**.**

Result and discussion:

The Arduino based gas sensor was able to sense the spoilage such as bad smell from the food. The level of emitted gas can be correlated with how much food is degraded. The system which includes embedded system along with sensors are sensitive to sense low emissions of the gases like Methane emitted due to spoilage of food. If the Methane gas detector records the volume of the gas item present in the food item further than a set position it gives the affair “Food is spoiled” and if doesn’t exceed the set position it gives the affair food is not spoiled. The amount of gases emitted is varying depending on the decay of food. The temperature & humidity sensor can be employed to sense the temperature & humidity content in the food. The condition of spoil for different item is given below.

Table: Different conditions of samples along with threshold value

S.N.	Sample	Threshold value	Remarks
1	Milk Sample 1	A1>1.3	Spoil
2	Milk Sample 2	A2<1.3	Normal
3	Banana sample 1	A1<1.3	Normal
4	Banana sample 2	A2>1.3	Spoil
5	Fish sample 1	A1>1.3	Spoil
6	Fish sample 2	A2<1.3	Normal

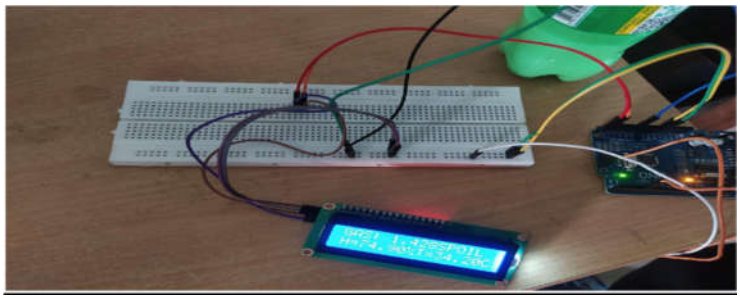


Figure 9 : The Arduino based gas sensor

Conclusion:

Food poisoning is a leading cause of various illnesses. To mitigate this risk, a food freshness detection system is employed. This system facilitates early detection of gases emitted by different food items, such as ammonia, methane, and ethylene, even before visible signs of spoilage appear. The gas sensors utilized in this system can identify gas emissions from food items, enabling consumers to monitor the perishability of their food. This empowers individuals to maintain their health and avoid consuming spoiled food. The integration of technology in the food processing industry enables manufacturers to indicate the perishable duration of their products on packaging. This facilitates proper control over consumption and minimizes food waste. Monitoring and detecting food spoilage is crucial, particularly for consumers who purchase packed food from malls, where the expiration date is a critical parameter. By using this technology, consumers can make informed decisions about their food choices, ensuring a safer and healthier dining experience.

Future scope:

Our project aims to detect the freshness of food but it has various limitations which can be improved with some advancement in technologies and application areas for future development.

Here are some methods discussed below:

Enhanced sensing technology:

Continued advancement in sensing technologies such as nanotechnology-based sensors, biosensors and spectroscopy will lead to more sensitive and accurate detection of food spoilage indicators like gases, Volatile Organic Compounds (VOCs) and microbial activity.

Integration with IoT and AI:

Integrating food spoilage detection systems with the Internet of Things (IoT) and Artificial Intelligence (AI) will enable real time monitoring and analysis of food conditions.

Add high quality detector:

High quality detector could be added to this device so that it can descry indeed the fewest corruption of food, where food is present in large amounts. This could be combined with an organic food tester which will test the quantum of germicides and fungicides present in the food.

Add pressure sensor**:**

Based onamount of calorie consumption a pressure sensor is included which helps to maintain a balanced diet.

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