International Research Journal on Advanced Engineering and Management
https://goldncloudpublications.com
https://doi.org/10.47392/IRJAEM.2025.0461
e ISSN: 2584-2854
Volume: 03
Issue: 09 September 2025
Page No: 2919 - 2925

# Smart Food Spoilage Detection and Notification System

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## Abstract
*Food spoilage is a significant cause of food waste in households, hostels, and small-scale food storage, creating both economic losses and health risks. This paper proposes a dual-mode Smart Food Monitoring System that provides automated detection and alerting for both packed and unpacked food items using a single integrated platform. For Packed Food Users enter product name, expiry date, and phone number via app. Provided information stored in PIC18F4520 microcontroller through Bluetooth (HC-05). The PIC18F4520 stores the data compared with the DS3231 RTC, checks expiry dates. The SIM800L GSM module sends SMS alerts two days before and on the expiry date. By combining expiry-date tracking for packaged items with sensor-driven spoilage detection for unpacked items, this system delivers a comprehensive, low-cost, and scalable solution for food monitoring. The proposed platform enhances food safety, reduces wastage, and supports smarter food management practices in residential and small commercial environments.*

***Keywords:*** *Bluetooth (HC-05), Food Safety, GSM SIM800L, MQ-135 Gas Sensor, PIC18F4520 Microcontroller, Real-Time Monitoring, RTC DS3231, Smart Food Monitoring, Waste Reduction.*

## 1. Introduction
Food spoilage is a major contributor to household and commercial waste, leading to economic loss and health hazards. According to recent studies, nearly one in every three units of food produced globally is wasted due to improper storage and missed expiration tracking [1]. Conventional methods of monitoring rely primarily on expiry dates printed on packaging, which are prone to being overlooked by users. For unpackaged food, spoilage often goes undetected until visible or olfactory signs appear, by which time the food is unsafe for consumption [2]. Smart food monitoring systems have been introduced to address this problem, including cloud-based refrigerators and mobile reminder applications [3]. However, these solutions often demand high infrastructure costs, internet connectivity, and complex image recognition techniques, limiting their adoption in rural or low-resource environments. To overcome this problem, we propose a low-cost, dual-approach food monitoring system using the PIC18F4520 microcontroller. The system monitors packed food by tracking expiry dates with an RTC and sending GSM-based SMS alerts, while unpacked food is monitored using an MQ-135 gas sensor for spoilage detection. By combining expiry tracking and real-time gas sensing, the system provides an affordable and practical solution for household food management

## 2. Literature Review
Researchers have explored various methods for food monitoring. RFID and barcode-based systems have been proposed for expiry date tracking [5], while IoT-enabled solutions integrate cloud platforms and mobile applications for inventory management [6]. Although effective, these approaches require internet connectivity, advanced infrastructure, or high costs, which limit their applicability in household scenarios [7]. For unpackaged food, gas sensors such as the MQ-series have been extensively studied for

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detecting volatile organic compounds like ammonia, methane, and $CO_2$ that are indicative of spoilage [8], [9]. These methods enable non-invasive, real-time monitoring; however, most studies remain laboratory-focused or restricted to single-product setups [10]. In addition, GSM-based alerting systems have been applied in agriculture, healthcare, and industrial safety, proving to be low-cost and reliable even in areas without internet access [11]. Despite these advancements, few works integrate both expiry date monitoring for packed food and spoilage detection for unpacked food into a unified system. Our proposed design addresses this gap by combining expiry tracking, gas sensing, and GSM-based alerts in a microcontroller-based solution [12].

## 3. Scope

At present, there is no single platform that can effectively manage both packaged and unpackaged food items in single platform. The cost of these refrigerators is relatively high, making them less affordable for the average household and small-scale business their reliance on advanced IoT infrastructure, mobile applications, and constant internet connectivity often makes them complicated to use, especially for non-technical users. As a result, while they do contribute to food management, their accessibility, affordability, and usability remain major challenges.

## 4. Proposed Method

The proposed work introduces a Smart Food Spoilage Alert System capable of monitoring both packed and unpacked food items on a single platform. The system is designed as a low-cost, microcontroller-based solution that minimizes food waste while ensuring safety and user convenience. For packed food, the user enters the product name and expiry date through a mobile application. The data is stored and tracked in real time using an RTC module. The system generates SMS alerts via a GSM module two days before and on the actual expiry date, ensuring that the user is notified in advance and does not miss critical information. This approach eliminates internet connectivity, making the system suitable for rural and low-resource environments. For unpacked food, spoilage detection is carried out using an MQ-135 gas sensor, which monitors volatile gases such as ammonia, methane, and carbon dioxide released during food decomposition. When the measured values exceed the pre-defined threshold, the microcontroller immediately triggers an SMS alert to the user, providing real-time spoilage detection.

## 5. Implementation

The Smart Food Spoilage and Notification System is designed to provide dual monitoring solutions. The approach combines hardware integration, sensor-based detection, and wireless technology ensures reliable and timely notification. The system employs the PIC18F4520 microcontroller as the CPU, interfaced with multiple peripheral modules. Users interact with the system through a mobile application, where they input food name, expiry date, and their phone number for packed food and enter Compartment no, phone no for unpacked food. This information is transmitted via the HC-05 Bluetooth module to the PIC microcontroller for processing and storage. Additional components such as the RTC (DS3231) to monitor packed food items and MQ-135 gas sensor to monitor unpacked food items and SIM800L GSM module are integrated to perform specialized tasks for monitoring and communication with users.

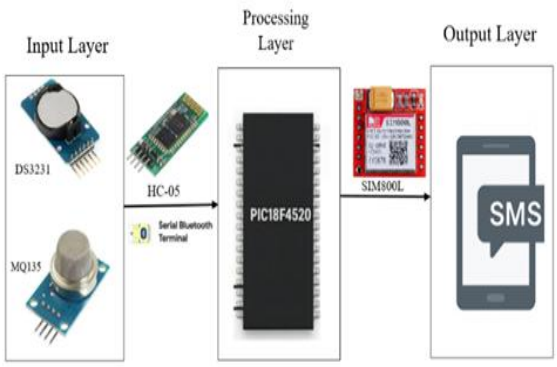


**Figure 1 System Implementation**

For packed food items, the manufacture mentions the product Name, expiry date and the phone no. Hence the mentioned expiry date we will compare with RTC module and GMS module for SMS alert for unpacked food, our system uses separate compartments, each integrated with an MQ-135 gas sensor. During storage, the user must place all vegetables in one compartment and all fruits in another compartment.

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When food begins to spoil, it releases gases such as ammonia, $CO_2$, alcohol and methane. Once the sensor detects these gases, the system immediately sends a notification to the user.

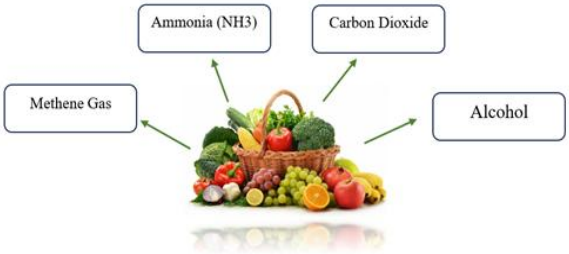


**Figure 2 Gases released from unpacked food spoilage**

The SIM800L GSM module sends SMS alerts two days before and on the expiry date. Once spoilage is detected or an expiry date is reached, the microcontroller communicates with the SIM800L GSM module to send SMS alerts directly to the user's phone no. This two-way mechanism ensures that packed food expiry is tracked proactively while unpacked food spoilage is identified in real time. By integrating hardware sensing with mobile communication, the system provides a reliable and user-friendly solution to food safety challenges.

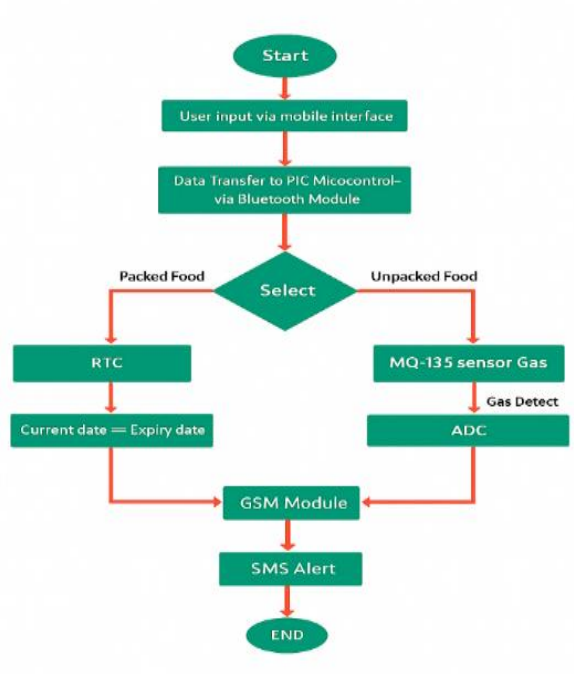


**Figure 3 Flowchart of System**

## 6. Hardware and Software

### 6.1. Hardware

#### 6.1.1. PIC18F4520 Microcontroller

The PIC18F4520 is a high-performance 8-bit microcontroller from Microchip's PIC18 family. It features 32 KB of Flash memory, 1.5 KB of RAM, and 256 bytes of EEPROM for program and data storage. It supports multiple communication protocols including USART, SPI, and I²C, making it versatile for embedded applications. The device integrates a 10-bit Analog-to-Digital Converter (ADC) with up to 13 input channels, enabling accurate sensor interfacing. Its operating speed of up to 40 MHz with an enhanced instruction set allows efficient real-time control. Owing to its low power consumption and rich peripheral set, the PIC18F4520 is widely used in automation, monitoring, and IoT-based systems.[12].

#### 6.1.2. RTC Module DS3231

The DS3231 Real-Time Clock (RTC) module is a highly accurate, I²C-based timekeeping device that keeps track of seconds, minutes, hours, day, date, month, and year. It features a temperature-compensated crystal oscillator for precision and includes a built-in battery backup to maintain time during power loss. With low power consumption and wide voltage compatibility (2.3V–5.5V), it is ideal for applications like data logging, alarms, and food monitoring systems where reliable and continuous time tracking is essential [13].

#### 6.1.3. MQ-135 Gas Sensor

The MQ-135 functions as an air quality monitoring sensor designed to detect harmful gases such as ammonia, methane, carbon dioxide, and other volatile organic compounds (VOCs). It provides an analog output proportional to the gas concentration, which can be processed by a microcontroller's ADC. Due to its high sensitivity, fast response, and low cost, the MQ-135 is widely used in environmental monitoring, food spoilage detection, and air quality control application [14].

#### 6.1.4. HC-05 Bluetooth Modul

The HC-05 Bluetooth module is a widely used serial communication device that enables wireless data exchange between microcontrollers, smartphones and Bluetooth-enabled devices. It supports the

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Bluetooth 2.0 standard and operates on the 2.4 GHz ISM band with a communication range of up to 10 meters. The module is simple to interface using UART (TX, RX) pins, making it ideal for short-range wireless applications such as remote monitoring, data logging, and control systems [15].

## 7. SIM800L GSM Module

The SIM800L GSM module is a communication device that allows microcontrollers to send and receive data and SMS messages over a mobile network. It operates using a SIM card, like mobile phones, and communicates with the microcontroller through serial UART pins. In IoT and embedded systems, GSM modules are widely used for real-time alerts, remote monitoring, and control applications where internet access is not always available [16].

### 7.1. Software

- Embedded C (MPLAB IDE + XC8 Compiler) Embedded C is used to program the PIC18F4520 microcontroller, ensuring efficient control of all hardware components. The development is carried out using MPLAB IDE, an integrated development environment by Microchip, which provides tools for coding, debugging, and simulation. The XC8 Compiler translates the Embedded C code into machine code compatible with the PIC architecture [12].
- Mobile App Interface The mobile application interface acts as the user-friendly bridge between the system and the user. As per requirement, users must select packed or unpacked food items they want to store.


**Figure 4 App Interface**

Now, if the user wants to store packed food, they need to enter the product name, expiry date, and their phone number through the app which are tracked in real-time using an RTC. This information is then transmitted to the microcontroller via Bluetooth (HC-05). Its intuitive design enhances accessibility, making the system more practical and user centric.

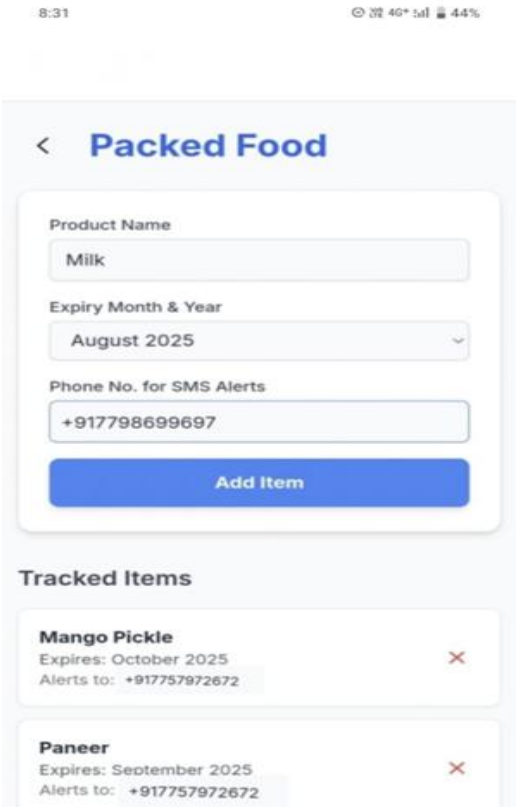


**Figure 5 App Interface for Packed Food**

For unpacked food, our system uses separate refrigerator compartments, each integrated with an MQ-135 gas sensor. The user enters the compartment name and their phone number for alerts. During storage, the user must place all vegetables in one compartment and all fruits in another compartment.

### 7.2. SMS alert

The SMS alert feature is implemented using the SIM800L GSM module, which communicates with the PIC18F4520 microcontroller through AT commands. When certain conditions are met, the microcontroller sends instructions to the GSM module. The GSM module then transmits an SMS notification to the stored phone number.

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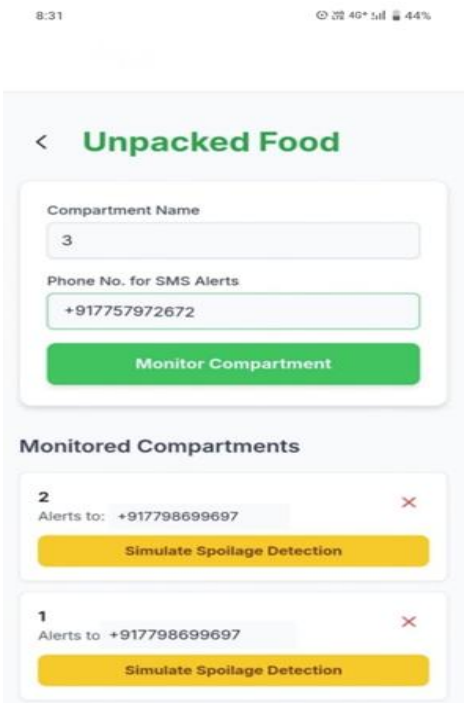


**Figure 6 App Interface for Unpacked Food**

Our system also sends a reminder notification two days before the food reaches its expiry or spoilage stage. This early alert gives users enough time to consume the food on time, reducing waste and improving food safety.

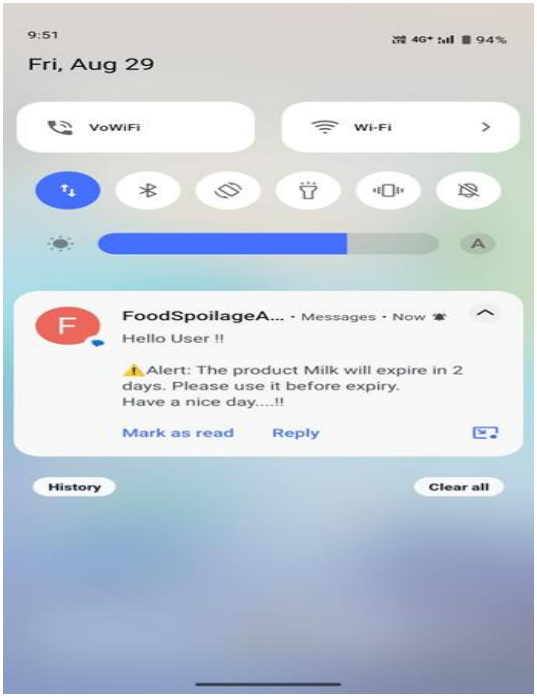


**Figure 7 Reminder SMS Alert for packed Food**

The system stores this data, and when the current date matches the expiry date, the user automatically receives a notification.

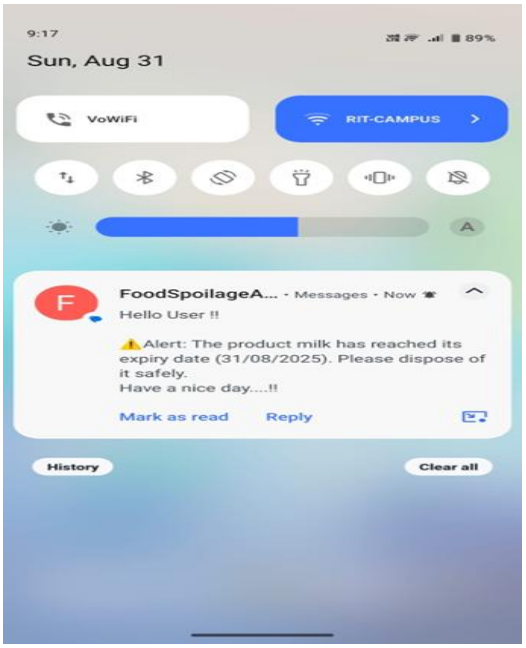


**Figure 8 SMS Alert for packed Food**

When food begins to spoil, it releases gases such as ammonia, $CO_2$, and methane. Once the sensor detects these gases, the system immediately sends a notification to the user.

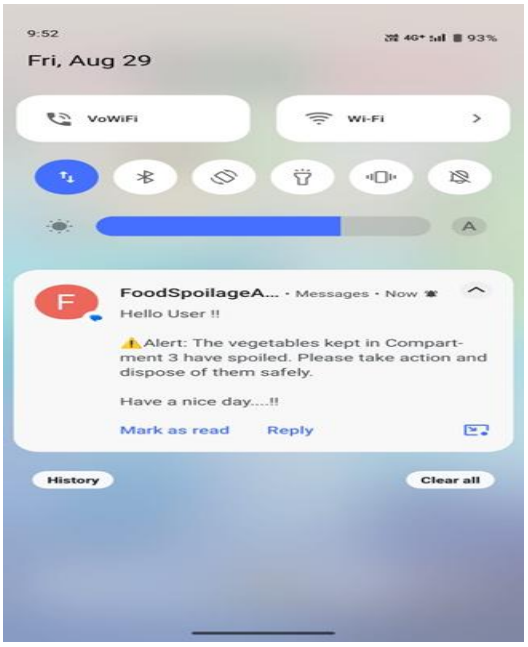


**Figure 9 SMS Alert for Unpacked Food**

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## 8. Discussion

In the market, smart refrigerators mainly work by keeping track of unpacked food items stored inside. When a food item is added, the user either enters the purchase details manually through the touchscreen or scans them using barcodes/QR codes. This data is stored in the refrigerator's memory, and since unpacked food generally has a limited freshness period of 2 to 8 days, the system monitors its storage duration. It keeps track of the purchase date, calculates the remaining freshness, and displays the results on the screen. This display helps users track the freshness and expiration of items such as meat, fish, and vegetables. However, this solution is only available for unpacked food, and currently there is no proper expiry date tracking system for packed food. Modern refrigerators also come with additional features such as built-in cameras to check fridge contents remotely through smartphone apps, and even voice command control to switch between fridge and freezer modes depending on user needs. Our proposed system goes beyond these features by providing SMS alerts for both packed and unpacked food. For packed food, the user enters the expiry date, which is compared with the real-time clock (RTC). The system then sends a reminder SMS two days before the expiry date, as well as on the exact day of expiry. For unpacked food, the system sends SMS alerts when gases such as methane, carbon dioxide, and alcohol are released due to spoilage, which are detected using the MQ-135 gas sensor for accuracy.
Although many innovative technologies have been implemented in refrigerators, there is still no reliable and low-cost solution for tracking the expiry of both packed and unpacked food.

## Conclusion

The Smart Food Spoilage Alert System offers a practical and efficient way to tackle food waste while ensuring consumer safety. It combines expiry date tracking for packed food with gas-sensor-based spoilage detection for unpacked food, supported by real-time SMS notifications. This dual functionality makes the system suitable for everyday use in homes, restaurants, and storage facilities. With its affordable design and simple interface, the system provides a smart solution that reduces waste, saves money, safeguards health, and encourages better food management practices.

## Acknowledgement

We are grateful to everyone who helped make this Smart Food Spoilage detection and notification System possible. Thanks to the support of Rajaram Bapu institute of technology, Rajaram Nagar college faculty and project team, we developed a dual monitoring system that tracks expiry dates of packed food and detects spoilage in unpacked food using gas sensors. With real-time SMS alerts and a user-friendly design, this system aims to reduce food waste, ensure safety, and promote smarter food management. Thank you for supporting this initiative!

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