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Research Article

Automated Food Quality Checking System

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ABSTRACT

Ensuring food safety, hygiene, and health is crucial in tackling the issue of food wastage. Preserving the high quality of food necessitates vigilant checking and safeguarding against deterioration caused by environmental factors such as temperature, humidity, and light. This research aims to develop a comparable tool for checking food quality, specifically focusing on environmental aspects like temperature, humidity, alcohol content, and light exposure for perishable items like fruits and vegetables. The system is constructed using an Arduino UNO microcontroller, which interfaces with various sensors like DHT-22 to track temperature and humidity, MQ3 to detect alcohol levels, and LDR to measure light exposure. The collected sensor data is transmitted to an IoT platform through an ESP8266 Wi-Fi Module. This IoT system serves to log and monitor the sensor data, enabling remote and real-time oversight of food storage conditions from any location and at any time.

1. Introduction

From both economic and social perspectives, ensuring food safety holds immense importance. A company's failure to meet food safety standards can have various consequences. Neglecting adequate food safety measures throughout the production process can profoundly affect the lives of individuals impacted by such lapses [1]. Without proper adherence to food safety and health protocols, contaminated foods might infiltrate the food supply chain. The discovery of faulty products can lead to substantial disruptions in the operations of the food service industry, as they grapple with managing the quality and recall of these items. The significance of food safety in today's society cannot be underestimated [2]. Global instances of over 200 preventable illnesses are largely attributed to issues with food safety and security. In the United States, one out of every ten individuals experience foodborne illnesses or injuries annually. Of the approximately 420,000 annual deaths resulting from consuming tainted food, over a quarter are children [3]. Hence, it becomes imperative to establish a system that aids consumers in determining the freshness and quality of food. This study presents a proposed food quality checking system. Previous research in this domain has been conducted. B. Yu et al. (2020) introduced a checking system that integrated smart contracts and evaluation models for automatically assessing the quality of fruit juice samples at each production stage [4]. A. Popa et al. (2019) proposed a food quality checking system for vegetables stored in vacuum-packed containers [5]. Young et al. (2018) has proposed two CNNs based models for different tasks: visibility estimation and recognizing Korean dishes from camera images in real-time [6]. However, this work only recognized various Korean dishes and not the quality of the food. Nonetheless, as far as our knowledge extends, a comprehensive food quality checking system for fruits, vegetables, and prepared foods such as curry and milk, encompassing all these aspects in a single framework, has yet to be developed.

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2. Methodology

The configuration diagram is illustrated in Fig.1, portraying the structural elements of the design. The system comprises power supply units, an Arduino UNO, a WIFI module, a Gas sensor (MQ3), an LDR, a pH sensor, a DHT22 sensor, and an LCD display. The lines connecting these components denote the system's input-output interactions. Central to the system's control is the Arduino Uno [7], which draws power from a 12V battery. The Arduino board, in conjunction with the DHT-22 [8], MQ3, LDR, and pH sensors, oversees parameters such as temperature, humidity, alcohol content, light exposure, and moisture. Thanks to its heightened sensitivity and rapid response time, measurements can be swiftly executed. The ESP8266 Wi-Fi Modem [9] establishes an internet connection through a Wi-Fi router, facilitated by the Arduino. Sensor data is concurrently displayed on a character LCD linked to the Arduino UNO. This IoT platform plays the dual role of logging and monitoring the sensor data. For more comprehensive monitoring and enhanced quality control, multiple devices can be strategically deployed on-site. Executing a spectrum of tasks, the Arduino Sketch software on the device manages tasks like obtaining sensor data, converting it into strings, displaying it on the character LCD, and transmitting it to the designated IoT platform, the Blynk Application. The list of components with its explanation is shown in Table 1.

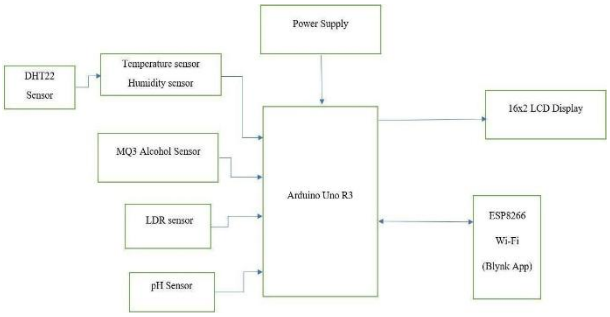

Fig. 1. Configuration diagram of the system

Table 1. List of components with its functions

Component	Function
DHT-22 sensor	To measure temperature and humidity. It encompasses two main components, namely the humidity detection unit and the NTC temperature sensor, which operates as a thermistor. Thermistors are adaptable resistors that alter their resistance in response to changes in temperature. These components jointly detect the ambient temperature and humidity, conveying this data to the integrated circuit (IC).
Light Dependent Resistor (LDR)	To discern light intensity. The LDR generates an analog voltage, which is subsequently converted into a digital output by the built-in ADC. The connection between the 16X2 LCD display and the Arduino board is established by linking the data pins to the board.
ESP8266 Wi-Fi Module	Serve as self-contained system-on-chip (SoC) capable of connecting to Wi-Fi networks, accompanied by an integrated TCP/IP protocol stack. The ESP8266 can either host applications or delegate all Wi-Fi networking functions to an external application processor. Each ESP8266 module arrives with pre-programmed AT instruction set software. This module exists in two variants, ESP-01 and ESP-12, with the ESP-12 offering 16 interface-accessible pins, while the ESP-01 provides 8 pins.
pH sensor	pH serves as the measurement unit for determining chemical acidity. The logarithmic representation of the hydrogen ion concentration, denoted as "H," defines pH. Spanning from 0 to 14 on the pH scale, a value of 7 signifies neutrality, as distilled water possesses a pH of 7. A pH exceeding 7 indicates alkalinity, while values below 7 indicate acidity. The pH scale gauges the acidity and basicity of a liquid, yielding values from 1 (most acidic) to 14 (most basic), with 7 representing neutrality. Analog pH sensing devices fulfill the purpose of ascertaining pH values, along with the substance's acidity or alkalinity. These devices find widespread applications in areas such as agriculture, wastewater treatment, industry, environmental monitoring, and more. Equipped with an onboard voltage control authority chip, the component accommodates a broad voltage range of 3.3-5.5V DC, rendering compatibility with control boards like Arduino that operate at both 5V and 3.3V.

The system flowchart for this project is illustrated in Fig. 2. It establishes a dedicated connection among the sensor units, the Wi-Fi component, and the microcontroller. The microcontroller preprocesses data from the three sensors before transmitting it to the web server. AT commands are employed to facilitate interaction between the Wi-Fi module and preprocessed data, sending it to the web server for further processing and visualization. Regular checks on the Wi-Fi module's status ensure a reliable network connection schedule. In case of disconnection in the Wi-Fi and web server connections, a link reset is executed. The web server analyzes and considers data from the Wi-Fi module. Upon device activation, the microcontroller initiates data processing over the Internet. Leveraging the Blynk Application, the Arduino can be controlled remotely via the Internet. A visual user interface is constructed through a digital dashboard to simplify the monitoring of sensor readings.

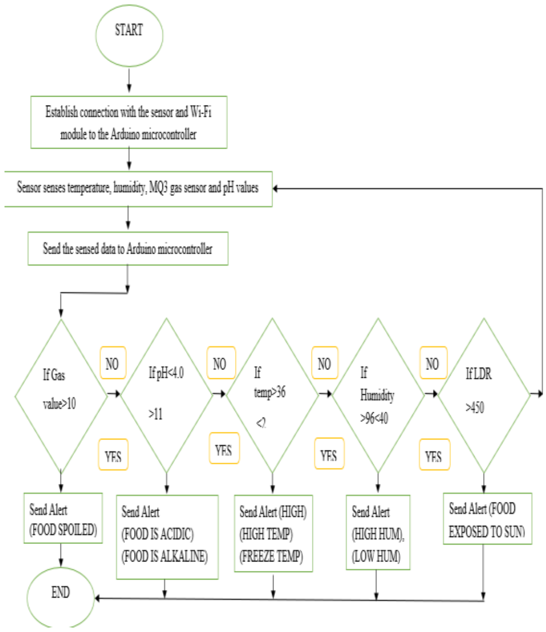

Fig.2. Flowchart of the proposed system

3. Findings

3.1. *Fruit Quality Detection*

Each variety of fruit and vegetable possesses distinct attributes, encompassing varying expiration dates, fragrances, and colors. Furthermore, diverse foods exhibit specific parameters such as humidity, temperature, and pH values. Alterations in temperature can also exert an influence on the process of food decay. Particularly for fruits and vegetables, maintaining the correct storage temperature is pivotal in prolonging their shelf life. Extreme temperature conditions have the potential to expedite the deterioration process. During freezing, water within plant cells transforms into ice crystals, leading to ruptured cell walls, discoloration, and a slimy texture. The DHT22 sensor proves useful in measuring both temperature and humidity. It operates effectively within a temperature range of -40 to +125°C, boasting an accuracy of ±0.5°C. Additionally, the DHT22 sensor can assess humidity across a range of 0 to 100 percent, demonstrating an accuracy level of 2 to 5 percent. This sensor's utilization highlights the possibility of preserving produce at lower temperatures to enhance freshness and flavor. Moreover, low temperatures impede the growth of pathogenic fungi that contribute to the spoilage of stored fruits and vegetables.

Continuing with the MQ3 Sensor, pivotal in detecting alcohol concentration in parts per million, this component serves a critical role in the system. The MQ3 Sensor detects gases emitted by ripening fruits, particularly ethylene gas, which aids in determining the spoilage status of fruits and vegetables. Substantial exposure to direct sunlight and limited airflow exhibits a uniform effect of hastening ripening and decay. Consequently, the LDR sensor is employed to gauge light intensity within the storage environment. Observations are thus conducted within the storage compartments for fruits and vegetables. The findings suggest that healthy fruit possesses resilient cell walls, maintaining optimal humidity levels and retarding rapid decay. Exposing fruits to high temperatures or direct sunlight can lead to a swift loss of natural moisture from their cell walls, resulting in a state of desiccation. To address this, an LDR sensor gauges the lux value of direct sunlight. If this value surpasses 450, users are alerted via both the Blynk App and the LCD screen. Furthermore, warmer days create conditions favorable for fungal growth and elevate the susceptibility of harmlessly feeding insects on the softer portions. Sunlight, due to its ability to cause cellular damage at a microscopic level through photodynamic degradation, also fosters fungal growth.
This study involves the use of two fruit types, Apples and Bananas, alongside a vegetable, Tomatoes. As depicted in Fig.3, the parts per million (ppm) values for the fruits and vegetables progressively rise each day. Bananas and Tomatoes exhibited spoilage on the 4th and 6th days, respectively, with recorded ppm values of 10 and 9. Similarly, Apples began to spoil on the 6th day, exceeding 10ppm. These results underscore that the release of Ethylene gas accompanies the decay of fruits and vegetables.

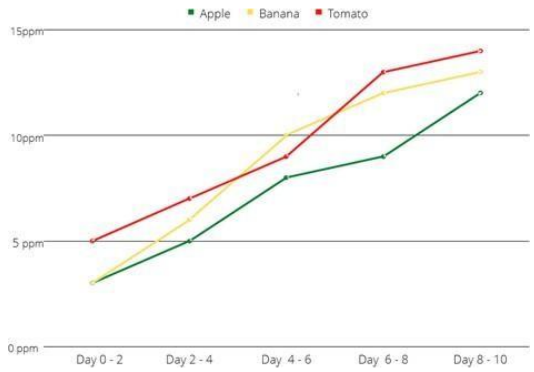

Fig.3: PPM values for Apple, Banana, and Tomato

3.2. IoT based Checking System

With the progress of associated software and hardware technologies, the utilization of the Internet of Things (IoT) has found extensive integration into our daily existence [10] [11]. An Internet of Things (IoT) application was employed to oversee the condition of food within the storage box of this system. To effectively monitor factors such as temperature, humidity, light intensity, ethylene gas concentration, and pH, five gauge-type widgets were incorporated (refer to Fig.4). The significance of the gauge widget's measurement is especially pronounced when evaluated as an average value compared to the maximum value. Nonetheless, a range of multiple values has been established, with the highest value displayed on Blynk's widget application, while the lowest value has been utilized. This configuration serves to present the data in the form of a gauge. The widget consistently showcases the most up-to-date information gathered. It's important to note that when the widget is set to "gauge" mode, the configuration field for the data series (which indicates maximum, minimum, or mean values of collected data) does not influence the presentation of the data.

3.3. Cooked Food Quality Detection

Detecting the humidity and temperature of cooked food is a straightforward process that aids in evaluating its quality. The assessment of cooked food quality can be facilitated through pH value analysis. A food's pH value provides insightful information: ranging from 0 to 6 signifies acidity, while values from 8 to 14 indicate alkalinity; a pH of 7 signifies neutrality. Distinct foods possess varying surface textures, with some being hard and others smooth. For instance, vegetables with resilient surfaces exhibit prolonged durability, while those with smoother surfaces tend to spoil earlier. Spoiled milk, stemming from an overgrowth of bacteria that compromises its quality, flavor, and texture, is a prime example. Once a milk carton is opened, environmental bacteria contribute to its microbial community, leading to potential spoilage. Over time, these microbial populations proliferate, eventually causing milk spoilage. Indications of spoilage manifest as an unpleasant, acidic odor, which can be pinpointed using a pH meter. As illustrated in Fig. 5, the pH values of both milk and curry exhibit a declining trend over successive days. Curry, for instance, experiences spoilage on the 2nd day, with its pH value falling below 6. In the case of milk, its pH value dips below 4 upon spoilage on the 3rd day. This underscores the increased acidity accompanying the decay of these foods. The proposed system offers the capability to measure and monitor real-time values, with the Blynk app serving as a tool for overseeing food conditions.

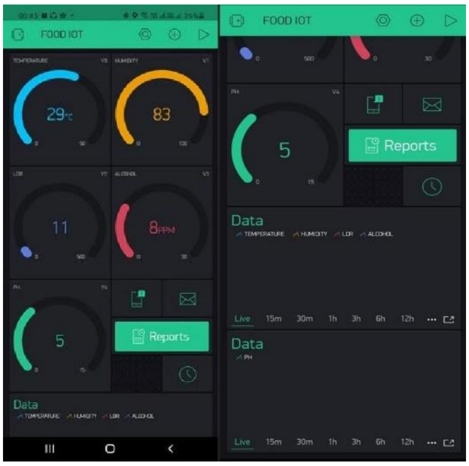

Fig. 4. Blynk Interface

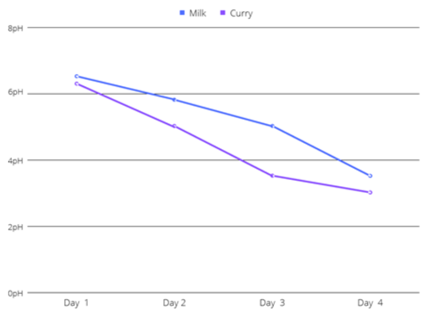

Fig. 5. pH Value for Milk and Curry

4. Conclusion

To sum up, the system exhibits the ability to oversee the temperature, humidity, alcohol levels, and light exposure within storage units containing fruits and vegetables. This is accomplished through the utilization of DHT22, MQ3, and LDR sensors. Moreover, the proposed system extends its functionality to detecting the spoilage of cooked foods, such as curry and milk, employing a pH sensor. By seamlessly transmitting data from the sensors to the IoT platform, namely the Blynk App, users gain the capability to remotely monitor the food's condition at their convenience, regardless of location and time. This system holds significant value for the food industry, as it facilitates continuous automated monitoring of food conditions. Further enhancement of the system's effectiveness can be achieved by incorporating image processing techniques.

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