

INTELLIGENT PACKING FOR REAL TIME MONITORING

Submitted in partial fulfillment of the
requirements for the award of
Bachelor of Engineering degree in Information technology

By

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SATHYABAMA

INSTITUTE OF SCIENCE AND TECHNOLOGY

(DEEMED TO BE UNIVERSITY)

Accredited with Grade "A" by NAAC

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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **M.RAHUMAN(39120089)** who carried out the Project entitled “**Intelligent Packing for Real time Monitoring of Food-Quality**” under my supervision from June 2022 to May 2023.

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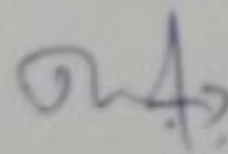
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DECLARATION

I, M. RAHUMAN (Reg.No- 39120086), hereby declare that the Project Phase-1 Report entitled **INTELLIGENT PACKING FOR REAL TIME MONITORING OF FOOD-QUALITY** done by me under the guidance of Dr. R. JEBERSON RETNA RAJ, M.TECH.,Ph.D is submitted in partial fulfillment of the requirements for the award of Bachelor of Engineering degree in Department of Information Technology.

DATE: 11/05/2023



PLACE: Chennai

SIGNATURE OF THE CANDIDATE

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ABSTRACT

Food packaging encompasses the topical role of preserving food, hence, extending the shelflife, while ensuring the highest quality and safety along the production chain as well as during storage. Intelligent food packaging further develops the functions of traditional packages by introducing the capability of continuously monitoring food quality during the whole chain to assess and reduce the insurgence of food-borne disease and food waste. To this purpose, several sensing systems based on different food quality indicators have been proposed in recent years, but commercial applications remain a challenge. This review provides a critical summary of responsive systems employed in the real-time monitoring of food quality and preservation state. First, food quality indicators are briefly presented, and subsequently, their exploitation to fabricate intelligent packaging based on responsive materials is discussed. Finally, current challenges and future trends are reviewed to highlight the importance of concentrating efforts on developing new functional solutions

Chapter No	TITLE	Page No.
	ABSTRACT	v
	LIST OF FIGURES	viii
	LIST OF TABLES	vii
1	INTRODUCTION	9
2	LITERATURE SURVEY	
	2.1 Inferences from Literature Survey	10
	2.2 Open problems in Existing System	16
3	REQUIREMENTS ANALYSIS	17
	3.1 Feasibility Studies/Risk Analysis of the Project	17
	3.2 Software Requirements Specification Document	18
4	DESCRIPTION OF PROPOSED SYSTEM	21
	4.1 Selected Methodology or process model	22
	4.2 Architecture / Overall Design of Proposed System	26
	4.3 Description of Software for Implementation and Testing plan of the Proposed Model/System	26
	4.4 Project Management Plan	27
5	IMPLEMENTATION DETAILS	29
6	RESULT AND DISCUSSION	31
7	CONCLUSION	
	7.1 Conclusion	33
	7.2 Future work	34
	7.3 Research Issues	35
	7.4 Implementation Issues	36
	REFERENCES	30
	APPENDIX	33
	A. SCREENSHOTS	33
	B. SOURCE CODE	36
	C. RESEARCH PAPER	42

LIST OF FIGURES

FIGURE NO	FIGURE NAME	Page No.
4.1	Arduino Uno board	21
4.2	MQ3 sensors	22
4.3	MQ2 sensors	22
4.4	DHT11 sensors	22
4.5	ESP8266 Wifi Module	22
4.7	System Architecture	27
A1	Working with sample	40
A2	Output with spoiled food	41
A3	Output with Good food	42

CHAPTER 1

INTRODUCTION

The article discusses the importance of food quality and safety, highlighting the significant number of illnesses and deaths related to foodborne contamination each year. The food industry has recognized the need for real-time monitoring of food preservation and quality to ensure consumer health, and efforts have been made to develop innovative packaging technologies that can provide this information.

Traditional packaging technologies act as passive barriers to prevent oxygen, moisture, and contaminants from coming into contact with food products. In contrast, innovative packaging technologies are active and intelligent, providing real-time quality insights and actively working to preserve food quality. These new materials have the potential to improve food safety, enhance food quality, and minimize food waste.

Active packaging technologies are an extension of traditional packaging systems, while intelligent packaging technologies evaluate food products and their surrounding environment in real-time, providing quality indicators such as pH, humidity, temperature, and specific chemicals. Optical sensors are increasingly being investigated as a low-cost, easy-to-read solution that can be used by untrained operators such as distribution chain operators and consumers. Optical sensors can be based on colorimetric assays, fluorogenic receptors, photonic structures, or plasmonic particles, and offer a promising solution for the real-time monitoring of food quality.

Despite the potential benefits of intelligent packaging technologies, the development of sensing technologies that can be used for industrial applications is still a challenge due to high costs, sophisticated instrumentation requirements, and integration issues with existing packaging materials. The article concludes with a discussion of the current challenges and future perspectives for the development of innovative packaging technologies for food quality monitoring.

CHAPTER 2

LITERATURE SURVEY

This section discusses the merits and demerits of the works which are done already related to the proposed work.

In [1] When conducting a literature review on the topic of food safety, it is important to first define your research question. This could involve exploring a specific aspect of food safety, such as the impact of packaging on foodborne illnesses. To gather relevant literature, search academic databases and government reports using relevant keywords related to your research question. Once you have identified potential sources, evaluate them by reviewing their abstracts and reading the full text of relevant sources. Analyze the sources you have collected, looking for common themes, findings, and limitations. Finally, synthesize the information you have gathered to draw conclusions and make recommendations for future research or policy.

Kotsanopoulos, et al. investigating and calculating the impact of foodborne diseases on global health. The report provides an overview of existing data on foodborne diseases and estimates of their consequences, including both morbidity and mortality rates [2].

Zhou, L.; Zhang, C, et al. analyses auditing, food safety, and food quality standards are all crucial factors in the food industry. By implementing these standards, food companies can improve their processes, prevent foodborne illnesses, and produce high-quality products that meet the expectations of consumers [3].

The article titled "Application of Deep Learning in Food: A Review" by Zhou et al. provides a comprehensive review of the use of deep learning in the food industry. the authors provide a valuable review of the current state of deep learning in the food industry and suggest potential areas for future research and development. This article is a useful resource for researchers and practitioners

interested in the applications of deep learning in the food industry[4].

Ali et al. suggest that supply chain integrity should be viewed as a strategic priority for food companies, as it can have a significant impact on their reputation, brand value, and financial performance. They conclude by calling for a multi-stakeholder approach that involves food producers, regulators, consumers, and other stakeholders in ensuring the safety and quality of the food supply chain [5].

Callao et al suggests Food fraud has become a major concern in the food industry due to its potential impact on public health, consumer trust, and the economy. As a result, there has been a growing interest in developing effective methods for detecting and preventing food fraud. To this end, multivariate qualitative methods have emerged as a promising approach for identifying patterns and abnormalities in complex data sets. In this literature review, we provide an overview of the key multivariate qualitative methods that are currently being used for food fraud detection. These methods include soft independent modeling of class analogy (SIMCA), principle component analysis (PCA), partial least squares discriminant analysis (PLS-DA), and Bayesian networks (BNs)[6].

Yousefi says there has been a growing interest in intelligent food packaging, which involves incorporating sensors and other technologies to monitor food quality and safety. This review highlights the significant potential of smart sensing technologies in the field of food packaging, and we discuss some of the challenges that must be addressed in order to fully realize this potential. We also provide some recommendations for future research in this area[7].

Dobrucka et. Al presents a comprehensive overview of the recent advancements and emerging trends in the area of active and intelligent food packaging. The authors discuss the current challenges and opportunities in this field, including the need for enhanced product safety, longer shelf-life, and improved quality control. The article highlights the role of active and intelligent packaging technologies in meeting these demands by incorporating functionalities such as moisture and oxygen barriers, antimicrobial agents, and temperature sensors. The authors also discuss the potential of these technologies to communicate important

information, such as freshness indicators, to consumers[8].

Hebbar proposes a system that uses IoT sensors and machine learning to detect the freshness of food. The literature review discusses existing techniques and their limitations, highlighting the need for more efficient and reliable methods. The proposed system shows promise in reducing food wastage and improving food safety[9].

Hui et al proposes a fuzzy-based storage assignment system for packaged food warehousing that uses intelligent techniques for optimal storage assignment. The literature review discusses existing methods and their limitations, highlighting the need for a more efficient and flexible approach. The proposed system uses fuzzy logic to assign storage locations based on various factors and outperformed a rule-based system in experiments. The proposed system shows promise in improving the efficiency of packaged food warehousing[10].

Jedermann et al discusses the use of smart sensors for intelligent containers in the context of the Internet of Things (IoT). The literature review highlights the challenges of ensuring the quality and safety of goods during transportation and the need for real-time monitoring of environmental conditions. The proposed solution uses smart sensors to monitor environmental conditions during transportation and transmit the data to a central system for analysis. The paper also discusses the potential benefits of the proposed solution, such as reducing waste, improving product quality, and increasing efficiency in logistics and supply chain management[11].

Gustavasson et al reviews on global food losses and food waste. It covers the extent of food losses and waste across the food supply chain, the causes of food losses and waste, and potential solutions to address this issue. The authors also discuss the role of technology and innovation in addressing food losses and waste. Overall, the paper stresses the need for collaboration and sustainability considerations in food systems planning and policy-making[12].

Jassen et al reviews on two underestimated threats in food transportation.

mold and acceleration. It discusses the impact of mold and acceleration on food quality and safety, as well as the current methods for detection and prevention. The authors emphasize the importance of considering these threats in food transportation and highlight the need for research and collaboration among stakeholders in the food supply chain to ensure the safety and quality of food during transportation[13].

Jedermann et al discusses the need for decision support systems in M2M networks for efficient and safe transportation of goods, especially in domains such as logistics and food transportation. The authors propose using smart dynamic software components to enable decision support in M2M networks and demonstrate their effectiveness in a simulated food transportation scenario[14].

Dannies et al explores the need for decision support systems in M2M networks for efficient and safe transportation of goods, particularly in logistics and food transportation. The authors propose using smart dynamic software components to facilitate decision support in M2M networks, demonstrating their effectiveness in a simulated food transportation scenario. The paper provides insights into the potential of M2M networks and highlights the need for efficient and safe transportation, offering an innovative approach with practical applications in various domains [15].

Cevikcan et al says warehouse storage policies in logistics, their challenges, and proposes a multi-objective assessment framework using fuzzy information axiom to handle uncertain and vague information. The framework is demonstrated to be effective in a case study, providing practical solutions for optimizing space utilization, accessibility, and cost-effectiveness [16].

J. Wang, X. Ding, and B. Guo et al proposes a high precision food detection method using a deep object detection network. The authors discuss the limitations of traditional methods for food detection and provide an overview of the proposed method's architecture, dataset, and experimental results. They also provide a brief review of existing methods for food detection and highlight the need for more accurate and efficient approaches[17].

The paper by D. Pandey et al. proposes an object detection method using transfer learning with YOLOv4 for accurate detection of food items in Indian food platters. The authors explain the challenges in food detection and provide a detailed methodology and experimental results. They also briefly discuss the limitations of existing methods for food detection [18].

The paper by D. M. Chiang et al. proposes an adaptive approach for storage assignment in distribution centers using data mining techniques. The authors explain the limitations of traditional methods, provide a detailed explanation of their proposed approach, and present experimental results demonstrating its effectiveness. In terms of literature review, the authors highlight the importance of efficient storage assignment and briefly discuss existing methods, emphasizing the need for more effective approaches. Overall, the paper contributes to the literature by proposing an adaptive approach that can potentially improve efficiency and reduce costs[19].

K. Choy et al. proposes an RFID-based storage assignment system to improve the efficiency of order picking in warehouses. The authors explain the limitations of traditional methods and provide a detailed description of their proposed system, including the use of RFID tags, readers, and an assignment algorithm. Experimental results show the system's effectiveness. In terms of literature review, the authors highlight the potential benefits of RFID technology, briefly discuss existing research, and emphasize the novelty of their proposed system. Overall, the paper contributes to the literature by proposing an innovative system that can potentially improve warehouse operations [20].

Henrichs et al. propose a novel system for monitoring food quality in real-time using smart sensors. The system involves the continuous monitoring of various food quality parameters such as temperature and humidity, followed by the analysis of the data using machine learning algorithms. The authors suggest that this adaptive system could be a promising solution to overcome the current limitations of traditional food quality monitoring methods. However, the system is still in its developmental phase and requires further validation before its implementation in

real-world scenarios [21].

The paper Herzberg et al. proposes the study involved a representative survey of 1,006 households and collected data on the types of food waste, reasons for waste, and disposal methods used. Key findings indicate that fruits and vegetables are the most commonly wasted food items, and households with more members tend to waste more food. The study also explores determinants of food waste, such as age, education, income, and household size. The paper emphasizes the need for research and policy interventions to reduce food waste and promote sustainability, which can help achieve global development goals[22].

The paper by henrichs et al. examines the challenges and limitations of digital twin technology, such as data privacy concerns and the requirement for specialized expertise. The authors conclude that digital twin technology has the potential to improve food quality and safety and revolutionize food production. This analysis provides valuable insights into the potential applications and challenges of digital twin technology in the food industry, which can inform further research and development in this emerging field [23].

The paper by fathi et al. examines the potential use of chipless radio frequency identification (RFID) sensors in food packaging applications. The paper also discusses the challenges and limitations of chipless RFID technology and offers potential solutions to address these challenges. Overall, this review provides a comprehensive analysis of the potential use of chipless RFID sensors in food packaging applications and offers insights into the current state-of-the-art and future research directions in this area [24].

2.2 Open problems in Existing System

Intelligent packing for real-time monitoring of food is a complex and challenging problem that requires the integration of various technologies and fields such as IoT, AI, sensors, and data analytics. Some of the open problems in this area include:

Reliable Sensor Technology: One of the major challenges in intelligent packing is the development of reliable sensors that can accurately detect changes in food quality and provide real-time data. Current sensor technologies have limitations in terms of accuracy, reliability, and durability. Therefore, the development of new sensor technologies that can overcome these limitations is essential.

Data Analytics: Another open problem in intelligent packing is the development of effective data analytics methods that can process the large volumes of data generated by the sensors. The analysis of this data requires sophisticated algorithms that can detect patterns, predict future trends, and identify potential problems.

Integration of IoT: The integration of IoT technologies is also a major challenge in intelligent packing. The different components of the packing system must be able to communicate with each other seamlessly, and data must be transmitted in real-time. The development of standard protocols for IoT integration is essential to ensure interoperability and reliability.

Security and Privacy: Another open problem in intelligent packing is ensuring the security and privacy of data. The use of IoT and AI technologies can potentially expose sensitive data, and it is essential to develop robust security mechanisms to prevent unauthorized access and data breaches.

Cost-Effectiveness: Finally, the development of cost-effective solutions is also an open problem in intelligent packing. The integration of various technologies and the development of new sensors and algorithms can be expensive, and it is essential to develop solutions that are affordable for small and medium-sized enterprises.

CHAPTER 3

REQUIREMENT ANALYSIS

3.1 FEASIBILITY STUDIES/RISK ANALYSIS OF THE PROJECT

The market for active, intelligent, and smart food packaging is rapidly increasing, with more than USD 38 billion worth of packages being sold in 2020 and about USD 50 billion expected by 2026. However, such systems are still scarcely applied due to their high cost compared to traditional packaging materials and the limited possibility of integration within the existing packages. Recent developments in chemistry, microelectronics, materials science, engineering, biotechnology, and nanotechnology may help in the design and fabrication of efficient, novel packaging solutions suitable for large-scale applications. For instance, food quality optical detection systems based on colorimetric sensors display great potential to overcome the current challenges, including the high cost and the requirement of sophisticated instruments. Such systems may provide a simple and easily readable indication concerning food quality over a long time period. Additionally, the sensitivity of such colorimetric devices and sensors may be even enhanced by integrating them with an RFID, aiming to achieve improved safety and quality, while reducing food waste and limiting costs. Specifically, colorimetric systems allow for easy read-out by any kind of user, including the consumers. The continuous advances in printed electronics via the deposition of conductive inks on various substrates are expected to favor the integration of intelligent sensors in packaging materials. However, it is noteworthy that the lack of standardized and comprehensive toxicity evaluation methods, as well as the often limited stability of the developed sensors, could generate the migration of substances in the food products. This poses a challenge in the large-scale fabrication and use of intelligent packages. Hence, the development and validation of standardized tests concerning the safety of future intelligent packages represents one of the main issues to be addressed before their effective large-scale usability. Moreover, it is critical to ensure that intelligent packaging is sustainable in terms of application, design, and production. This is vital not only to improve the management of the food supply chain but also to reduce global food waste and environmental pollution. Specifically, the growing

environmental burden related to petroleum-derived plastics imposes the enrichment of packaging products with eco-friendly features. However, to date, intelligent devices such as colorimetric and optical tags and especially RFDI and sensors are often not yet designed in respect of recyclability and/or sustainability mechanisms, since their main purpose is to improve food shelf-life by being as cheap and functional as possible. Hence, naturally occurring polymers based on renewable resources, such as cellulose and chitosan, may represent considerable areas of innovation and exciting opportunities for the inexpensive, safe, and sustainable fabrication of eco-friendly intelligent packaging materials. In conclusion, this review critically discusses the most common optical approaches and emerging technologies for real-time food monitoring and addresses topics related to their future development for large-scale food packaging applications. These are usually based on different types of food quality indicators (i.e., pH, O₂, CO₂, temperature, etc.) and can provide information for consumers as regards product safety.

3.2 SOFTWARE REQUIREMENTS SPECIFICATION DOCUMENT

To implement the FQMS following are the requirements:

3.2.1 Hardware needed

- 1) Arduino Uno board: This board has ATmega328P micro controller which has 14 GPIO pins, 6 PWM pins, 6 analog input pins and is programmable with the Arduino IDE. It can run on USB power. This board allows many different external peripheral connections like Wi-Fi, Bluetooth and Ethernet.
- 2) DHT11 Sensor: This sensor mainly consists of two parts a capacitive humidity sensor and thermistor. It converts the analog data to digital signal which indicates the humidity and temperature
- 3) MQ3 Sensor: It is used to sense the presence of alcohol using SnO₂ as the sensitive material. The concentration of alcohol gas in the environment increases

the conductivity of the sensing material, using which the alcohol presence in the environment can be determined.

4) MQ2 Sensor: MQ2 Sensor is used to detect the presence of gas or smoke. It detects it by the change of resistance in sensing material when there is a presence of smoke in the surrounding.

5) Load cell Sensor: It is a transducer that converts force into an electrical signal. Any change in the force causes a change in the output electrical signal.

7) ESP8266 Wifi Module: It is a system on chip (SoC) module that is preprogrammed with TCP/IP protocol stack which gives an access for the microcontroller to a Wifi network. It is mostly used for various IoT applications.

3.2.2 Web platforms needed

- 1) Thing speak: It is a free source that uses HTTP protocol to store or retrieve data from things. The information can be used for further analysis in IoT application.
- 2) MIT app inventor: It is a web application that allows the developer to create application software for operating systems. It is easy to build fully functional apps as it uses block- based programming.

3.2.3 Software needed

- 1) Arduino IDE: It is free source Arduino software that helps to write codes and program Arduino board. This software is compatible with any type of Arduino board. The Arduino IDE is an open-source software, which is used to write and upload code to the Arduino boards. The IDE application is suitable for different operating systems such as **Windows, Mac OS X, and Linux**. It supports the programming languages C and C++. Here, IDE stands for **Integrated Development Environment**. The program or code written in the Arduino IDE is often called as sketching. We need to connect the Genuino and Arduino board with the IDE to

upload the sketch written in the Arduino IDE software. The sketch is saved with the extension ".ino."

CHAPTER 4

DESCRIPTION OF PROPOSED SYSTEM

Food packaging encompasses the topical role of preserving food, hence, extending the shelf-life, while ensuring the highest quality and safety along the production chain as well as during storage. Intelligent food packaging further develops the functions of traditional packages by introducing the capability of continuously monitoring food quality during the whole chain to assess and reduce the insurgence of food-borne disease and food waste. To this purpose, several sensing systems based on different food quality indicators have been proposed in recent years, but commercial applications remain a challenge. This review provides a critical summary of responsive systems employed in the real-time monitoring of food quality and preservation state. First, food quality indicators are briefly presented, and subsequently, their exploitation to fabricate intelligent packaging based on responsive materials is discussed. Finally, current challenges and future trends are reviewed to highlight the importance of concentrating efforts on developing new functional solutions.



Fig 4.1. Arduino Uno board



Fig 4.1 MQ3 sensors



Fig 4.3 MQ2 sensors

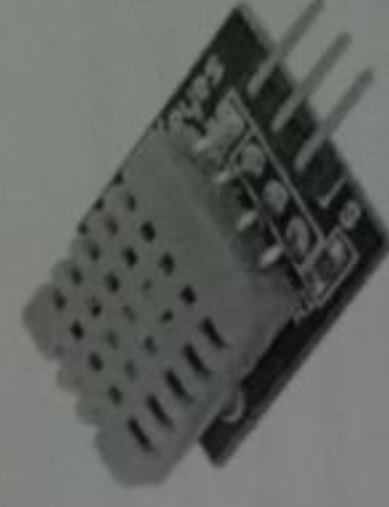


Fig 4.4 DHT11 sensors

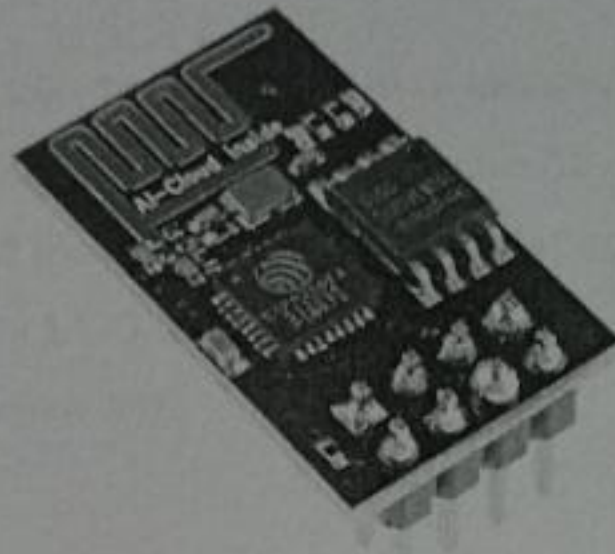


Fig 4.5 ESP8266 Wifi Module

4.1 SELECTED METHODOLOGY OR PROCESS MODEL

Food safety and hygiene is a major concern in order to prevent the food wastage. The Quality of the food needs to be monitored and it must be prevented from rotting and decaying by the atmospheric factors like temperature, humidity and dark. Therefore, it is useful to deploy quality monitoring devices at food stores. These quality monitoring devices keep a watch on the environmental factor that cause or pace up decay of the food. Later, the environmental factors can be controlled like by refrigeration, vacuum storage etc.

In this project, a similar food quality monitoring device will be designed that will keep watch of environmental factors like temperature, humidity, alcohol content and exposure to light. The device is built on Arduino UNO which is a popular prototyping board. The Arduino board is interfaced with various sensors like DHT-11 to monitor temperature and humidity, MQ3 to detect alcohol content and LDR to measure exposure to light. This is an IoT device and sends the measured sensor data to an IoT platform. The ESP8266 Wi-Fi Modem is interfaced with the Arduino to connect it to the internet via Wi-Fi router. The sensor data is also displayed on a character LCD interfaced with the Arduino UNO. The IoT platform used for logging and monitoring of sensor data is Freeboard.io. With the power of Internet of Things, the environmental factors affecting the food storage can be monitored from anywhere, anytime and from any device.

Many such devices can be installed at a location for better monitoring and quality control. The Arduino Sketch running over the device implements the various functionalities of the project like reading sensor data, converting them into strings, displaying them on character LCD and passing them to the IoT platform. The Sketch is written, compiled and loaded using the Arduino IDE.

The project consists of sensors and Arduino as micro controller. Monitoring, Tracking, Controlling. Proposes a system using Bluetooth Low Energy and IoT technology, to trace the food quality throughout the circulation by using an electronic tag.

A. Arduino Uno board:

The Arduino Uno is a micro controller board that utilizes the ATmega328P microprocessor. It is one of the most popular Arduino boards and is extensively utilized in a wide range of projects, from basic hobby projects to complicated industrial applications. The board contains 14 digital input/output pins, 6 analogue inputs, a quartz crystal with a frequency of 16 MHz, a USB connection, a power connector, an ICSP header, and a reset button. The Arduino Integrated Development Environment (IDE) is a simple and user-friendly platform for creating and uploading code to the board that may be used to programme it. The adaptability of the Arduino Uno board is one of its primary strengths.

It can be used to control various sensors, motors, and other electronic components, making it a popular choice for robotics projects, home automation systems, and interactive art installations. The board can also be easily connected to other devices and systems, such as smartphones, computers, and the internet, using various communication protocols and interfaces. Overall, the Arduino Uno board is a powerful and flexible tool for electronics enthusiasts and professionals alike, and its popularity is a testament to its reliability, ease of use, and versatility.

B. DHT11 Sensor: The thermistor and capacitive humidity sensor make up the majority of this sensor. It transforms analogue data into a digital signal that displays

temperature and humidity

C. MQ3 Sensor:

It is used to sense the presence of alcohol using SnO₂ as the sensitive material. The concentration of alcohol gas in the environment increases the conductivity of the sensing material, using which the alcohol presence in the environment can be determined.

D. MQ2 Sensor:

The presence of gas or smoke is detected by the MQ2 Sensor. It detects smoke in the surroundings by altering the resistance of the sensor material.

E. ESP8266 Wifi Module:

It is a system on chip (SoC) module preprogrammed with a TCP/IP protocol stack that allows the microcontroller to connect to a WiFi network. It is typically utilised for various IoT applications.

F. Thingspeak:

ThingSpeak is an Internet of Things (IoT) analytics platform that allows users to collect, analyze, and visualize data from sensors or other IoT devices. It provides a cloud-based platform that enables users to store and analyze their IoT data, as well as build applications based on that data.

ThingSpeak is a powerful tool for collecting and analyzing data from IoT devices, allowing users to gain insights and make data-driven decisions based on their data.

The three sensors in this project - Dh11, MQ2, and MQ3 - are all capable of detecting certain properties of food that can help to identify when it has spoiled and is no longer safe to eat.

The Dh11 sensor can measure both temperature and humidity levels in the surrounding environment. When food spoils, it often undergoes a change in temperature and humidity due to the growth of bacteria and other microorganisms. By monitoring these changes with the Dh11 sensor, it may be possible to detect when food has spoiled.

The MQ2 sensor is specifically designed to detect the presence of methane gas, which is a byproduct of the decomposition of organic matter. As food spoils, it releases gases like methane, which can be detected by the MQ2 sensor. By monitoring the methane content in food, it may be possible to determine if the food has spoiled and is no longer safe to eat.

The MQ3 sensor, on the other hand, is designed to detect the presence of alcohol vapors. While not all spoiled food will contain alcohol, some types of spoilage can produce alcohol as a byproduct. By monitoring the alcohol content in food with the MQ3 sensor, it may be possible to detect spoilage and determine if the food is safe to eat.

Then the data is shared to Thingspeak through a wifi module, then using thingspeak we can show the visualization and monitor the sensors.

Overall, by combining the data from all three sensors, it may be possible to identify a pattern of changes that occur when food spoils, such as an increase in humidity, methane content, or alcohol content. By detecting these changes early on, it may be possible to prevent the consumption of spoiled food and reduce the risk of foodborne illness.

4.2 ARCHITECTURE / OVERALL DESIGN OF PROPOSED SYSTEM

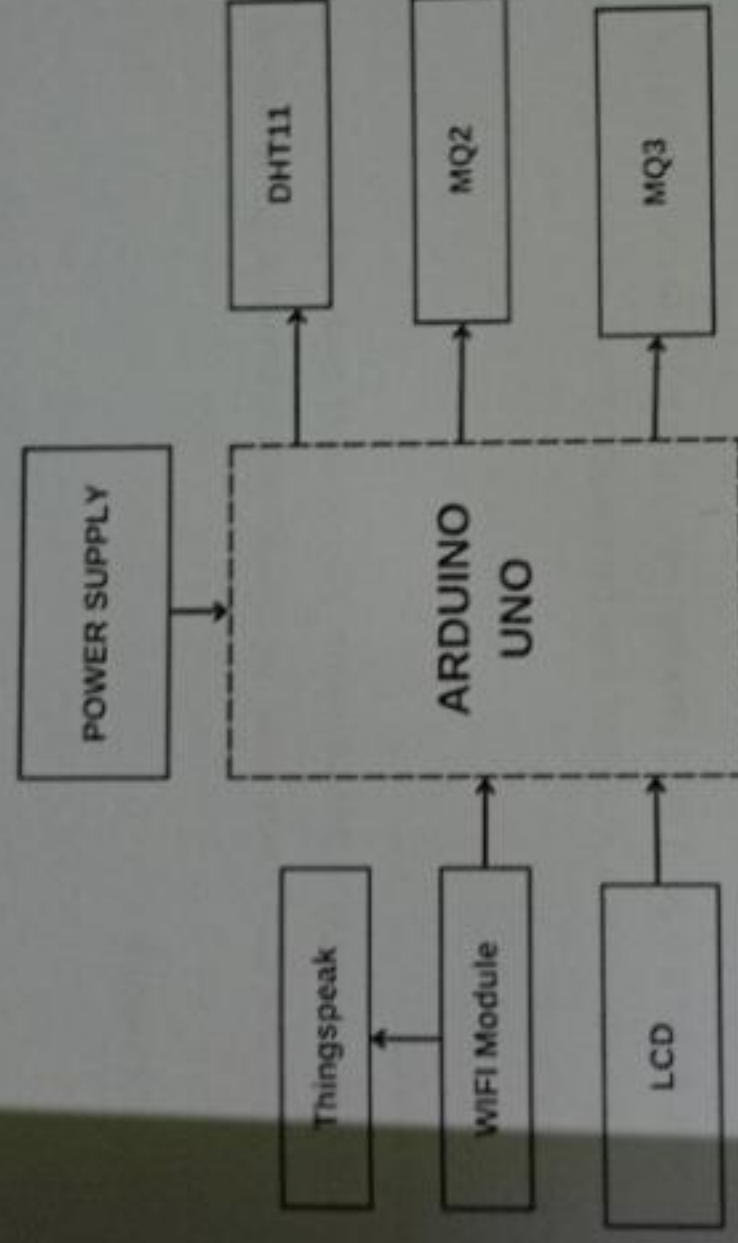


Fig 4.7: System Architecture

The Internet of Things (IoT) is an emerging idea that involves linking devices to the internet utilizing sensors, actuators, and other identifying and sensing technologies to enable smart recognition, placement, tracing, and management. Intelligent sensor, wireless communication, and radio frequency identification (RFID) technologies are all combined in the IoT sensing system. In order to create a visibility and traceability system for handling perishable food, the Internet of Things is therefore possible.

4.3 DESCRIPTION OF SOFTWARE FOR IMPLEMENTATION AND TESTING PLAN OF THE PROPOSED MODEL/SYSTEM

The IoT based FQMS for fruits and vegetables warehouses has three basic functions and the block diagram

4.3.1 Monitoring

The physical parameters like light intensity, humidity and temperature are constantly monitored in real time using sensors.

4.3.2 Controlling

The real time value from the sensor is compared to the threshold values and brought back to the required value. List of fruits and vegetable with their ambient requirements

4.3.3 Tracking

The above two functions can be tracked using an app, which will also notify the user when the food gets spoiled, when the stock is over and if there is any fire hazard.

4.3.4 Methods for Real-Time Food Monitoring

The European Commission has defined intelligent food packages as "materials And articles that monitor the condition of packaged food or the environment surrounding The food". Generally speaking, intelligent packaging can be explained as a combination of science and technology able to enhance the shelf-life, improve safety, guarantee the quality, and warn about any harmful changes occurring in the packages. Specifically, intelligent packaging makes use of the internal or external package environment to monitor the food quality status [13,19,65]. A summary of the most common methods currently employed for the real-time monitoring of food samples based on the indicator nature is discussed in the following.

4.4 PROJECT MANAGEMENT PLAN

IoT is an emerging concept for connecting objects or things with the internet using sensors, actuators and other identification and sensing technologies so as to achieve smart recognitions, positioning, tracing, monitoring and administration. The

IoT sensing system combines the features of intelligent sensor, wireless communication and radio frequency identification (RFID) technology. Therefore, Internet of things is feasible in establishing a visibility and traceability system in handling perishable food. In basic sensors such as temperature, humidity and light sensor are used to monitor different parameters that causes food spoilage and then the data is sent to the cloud. The user is notified about the quality changes using IoT technology and can control the spoilage of food manually or automatically. Proposes a system using Bluetooth Low Energy and IoT technology, to trace the food quality throughout the circulationby using an electronic tag. Uses an IoT system that has an infrared camera to capture images of leafy food in the field. The data is then sent to an Arduino processor via a Wifi module and a decision is made based on the data.

CHAPTER 5

IMPLEMENTATION DETAILS

5.1 Development and Deployment Setup

To develop and deploy an intelligent packing system for real-time monitoring of food, the following setup is required:

Hardware:

- **Sensors:** Depending on the type of food being monitored, different sensors such as temperature sensors, humidity sensors, gas sensors, and pH sensors will be required.
- **Microcontrollers:** The microcontrollers will be used to read data from the sensors and transmit it to the cloud.
- **Gateways:** The gateways will be used to collect data from multiple microcontrollers and transmit it to the cloud.
- **Cloud Infrastructure:** The cloud infrastructure will be used to store and process the data generated by the sensors.

Software:

- **Data Analytics:** Software tools will be used to analyze the data generated by the sensors to identify patterns, predict future trends, and identify potential problems.
- **User Interface:** A user interface will be developed to allow users to monitor the status of the food in real-time and receive alerts when there are any issues.
- **Communication Protocols:** Standard communication protocols such as MQTT, HTTP, and HTTPS will be used to ensure interoperability and reliability between different components of the system.

Deployment:

- The microcontrollers and sensors will be installed in the food packaging and connected to the cloud infrastructure using gateways.
- The data analytics software and user interface will be deployed on the cloud infrastructure.
- The communication protocols will be configured to ensure reliable data transmission between the different components of the system.

Testing:

- The system will be tested to ensure that the sensors are accurately detecting changes in food quality and transmitting data to the cloud in real-time.
- The data analytics software will be tested to ensure that it can effectively process and analyze the data generated by the sensors.
- The user interface will be tested to ensure that it provides users with real-time information about the status of the food and alerts them when there are any issues.

In summary, developing and deploying an intelligent packing system for real-time monitoring of food requires a combination of hardware, software, and communication protocols. The system must be carefully tested to ensure that it is accurate, reliable, and meets the needs of the users.

CHAPTER 6

RESULTS AND DISCUSSION

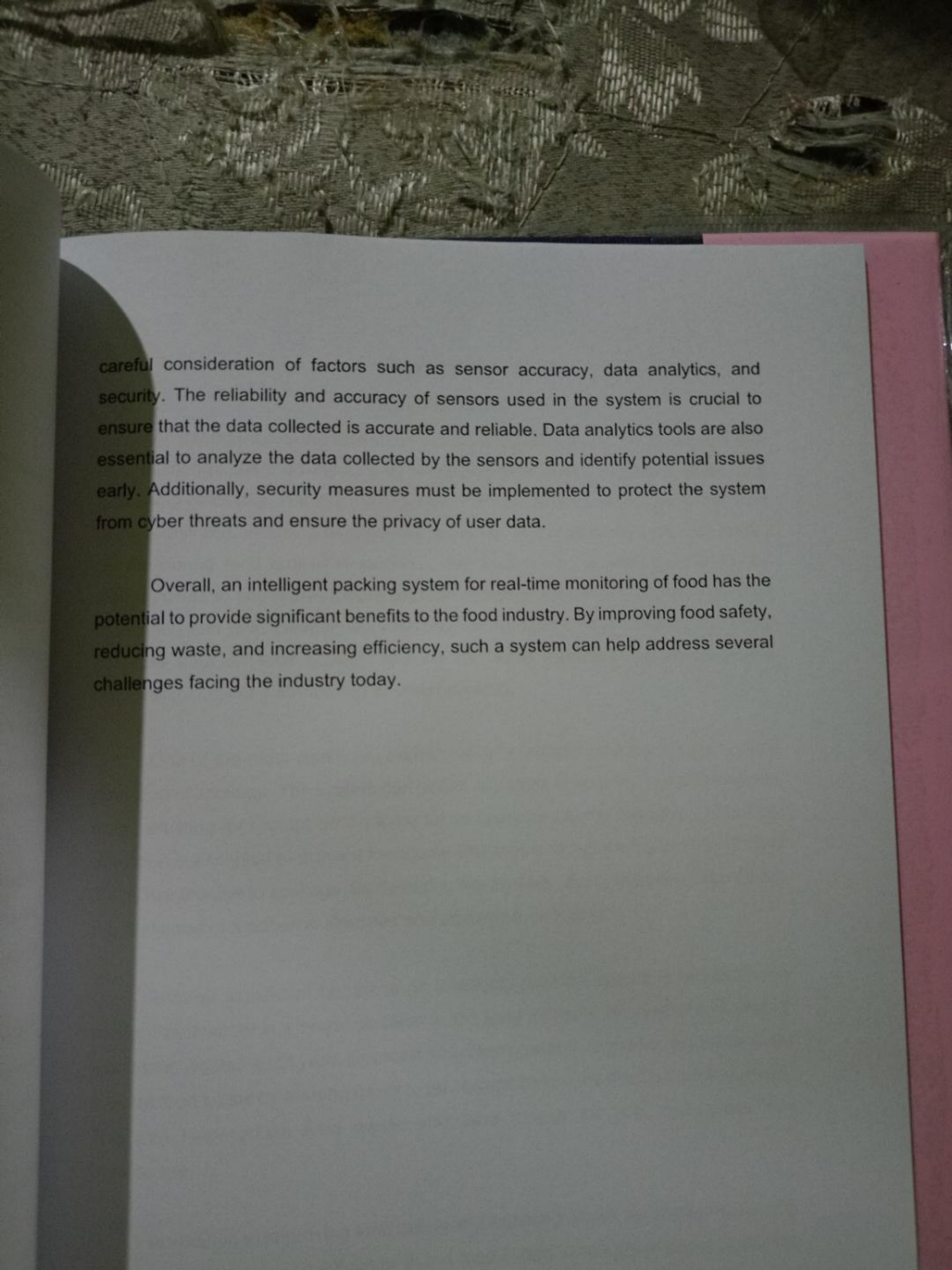
The results of an intelligent packing system for real-time monitoring of food would include:

- Real-time monitoring of food quality: The system will provide real-time data on the quality of the food being monitored, including temperature, humidity, gas composition, and pH levels.
- Early detection of spoilage: The system will detect any signs of spoilage or contamination early, allowing for prompt action to be taken to prevent further damage.
- Reduced food waste: By monitoring food quality in real-time, the system can prevent food waste by alerting users to any issues before the food becomes spoiled.
- Improved efficiency: The system can help improve the efficiency of the food supply chain by providing real-time data on food quality, allowing for better planning and management of inventory.

Discussion:

An intelligent packing system for real-time monitoring of food can provide several benefits, including improved food safety, reduced waste, and improved efficiency. By detecting spoilage and contamination early, the system can help prevent foodborne illnesses and reduce the amount of food that is wasted due to spoilage. In addition, real-time monitoring can help improve the efficiency of the food supply chain by providing accurate data on food quality, allowing for better inventory management and reducing the risk of overstocking or understocking.

However, the implementation of such a system can be challenging and requires



careful consideration of factors such as sensor accuracy, data analytics, and security. The reliability and accuracy of sensors used in the system is crucial to ensure that the data collected is accurate and reliable. Data analytics tools are also essential to analyze the data collected by the sensors and identify potential issues early. Additionally, security measures must be implemented to protect the system from cyber threats and ensure the privacy of user data.

Overall, an intelligent packing system for real-time monitoring of food has the potential to provide significant benefits to the food industry. By improving food safety, reducing waste, and increasing efficiency, such a system can help address several challenges facing the industry today.

CHAPTER 7

CONCLUSION

An intelligent packing system for real-time monitoring of food has the potential to revolutionize the food industry by improving food safety, reducing waste, and increasing efficiency. The system provides real-time data on the quality of the food being monitored, including temperature, humidity, gas composition, and pH levels. By monitoring food quality in real-time, the system can prevent food waste by alerting users to any issues before the food becomes spoiled. In addition, real-time monitoring can help improve the efficiency of the food supply chain by providing accurate data on food quality, allowing for better inventory management and reducing the risk of overstocking or understocking.

One of the most significant benefits of an intelligent packing system is early detection of spoilage. The system can detect any signs of spoilage or contamination early, allowing for prompt action to be taken to prevent further damage. This early detection is essential to prevent foodborne illnesses and reduce the amount of food that is wasted due to spoilage. By detecting issues early, the system can help reduce the likelihood of foodborne illnesses and improve food safety.

Another significant benefit of an intelligent packing system is reduced food waste. Food waste is a major problem in the food industry, with millions of tons of food being wasted each year. By monitoring food quality in real-time, the system can prevent food waste by alerting users to any issues before the food becomes spoiled. This can help reduce food waste and save money for both consumers and businesses.

In addition to improving food safety and reducing waste, an intelligent packing system can also increase efficiency in the food supply chain. By providing real-time data on food quality, the system can help improve inventory management and reduce the risk of overstocking or understocking. This can help businesses save money and reduce waste by ensuring that they have the right amount of inventory on hand at all times.

However, the implementation of such a system is not without challenges. The reliability and accuracy of sensors used in the system are crucial to ensure that the data collected is accurate and reliable. Data analytics tools are also essential to analyze the data collected by the sensors and identify potential issues early. Additionally, security measures must be implemented to protect the system from cyber threats and ensure the privacy of user data.

In conclusion, an intelligent packing system for real-time monitoring of food has the potential to bring significant benefits to the food industry, including improved food safety, reduced waste, and increased efficiency. However, it is important to carefully evaluate and test such a system to ensure that it is accurate, reliable, and secure. With careful consideration of the challenges and implementation of necessary measures, an intelligent packing system can help revolutionize the food industry and bring benefits to both consumers and businesses.

7.2 Future work

There are several areas for future work to further improve the functionality and effectiveness of an intelligent packing system for real-time monitoring of food.

Firstly, there is a need to improve the accuracy and reliability of the sensors used in the system. New technologies and materials can be explored to develop more accurate and robust sensors for detecting various parameters such as temperature, humidity, gas composition, and pH levels.

Secondly, the development of more sophisticated algorithms and data analytics tools can enhance the system's ability to detect potential issues early and provide insights into food quality and safety. Machine learning algorithms can be used to identify patterns in the data collected by the sensors and make predictions on the likelihood of spoilage or contamination.

Thirdly, there is a need to further enhance the system's security measures to protect it from cyber threats and ensure the privacy of user data. As the system

involves sensitive information on food quality and safety, robust security measures such as encryption and authentication protocols must be implemented.

Finally, the integration of the intelligent packing system with other systems in the food supply chain can improve its overall effectiveness. For example, the system can be integrated with logistics and inventory management systems to optimize the distribution of food products and reduce waste.

In conclusion, future work in improving the accuracy and reliability of sensors, developing more sophisticated algorithms and data analytics tools, enhancing security measures, and integrating the intelligent packing system with other systems in the food supply chain can further improve the functionality and effectiveness of real-time monitoring of food.

7.3 Research Issues

There are several research issues that must be addressed in the development and implementation of an intelligent packing system for real-time monitoring of food. The accuracy and reliability of sensors used in the system must be evaluated and tested to ensure that the data collected is accurate and reliable. Research must be conducted to develop and optimize sensors for detecting various parameters such as temperature, humidity, gas composition, and pH levels. Research must be conducted to develop and optimize algorithms and data analytics tools to process and analyze the data collected by the sensors. This includes the development of machine learning algorithms to identify patterns in the data and make predictions on the likelihood of spoilage or contamination.

Thirdly, research must be conducted to ensure the security and privacy of user data collected by the system. This includes the development of robust security measures such as encryption and authentication protocols to protect the system from cyber threats.

Fourthly, research must be conducted to evaluate the cost-effectiveness of the system and its impact on the food industry. This includes analyzing the costs of implementing the system and the potential benefits of improved food safety, reduced waste, and increased efficiency.

Finally, research must be conducted to evaluate the scalability of the system

and its ability to handle large volumes of data. As the system involves real-time monitoring of food quality, it must be able to handle large volumes of data in real-time and scale to meet the needs of businesses of various sizes.

In conclusion, addressing research issues related to the accuracy and reliability of sensors, development of algorithms and data analytics tools, security and privacy of user data, cost-effectiveness, and scalability is essential for the successful development and implementation of an intelligent packing system for real-time monitoring of food.

7.4 Implementation Issues

The implementation of an intelligent packing system for real-time monitoring of food involves several critical issues that must be considered to ensure its successful development and deployment. Hardware and software components must be carefully selected to ensure accurate and reliable data collection and real-time processing and analysis. The system must be compatible with existing systems in the food supply chain, such as inventory management and logistics systems, to optimize distribution and reduce waste. User acceptance and training are also crucial to ensure that users can interpret the data collected by the sensors and insights provided by analytics tools. The system must be equipped with robust security measures to protect it from cyber threats and ensure the privacy of user data. Finally, regular maintenance and updates must be performed to ensure the continued effectiveness of the system and incorporate new technologies and features to enhance its functionality. Addressing implementation issues related to hardware and software selection, compatibility and integration, user acceptance and training, security and privacy, and maintenance and updates is critical for the successful development and deployment of an intelligent packing system for real-time monitoring of food.

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APPENDIX
A.SCREENSHOTS

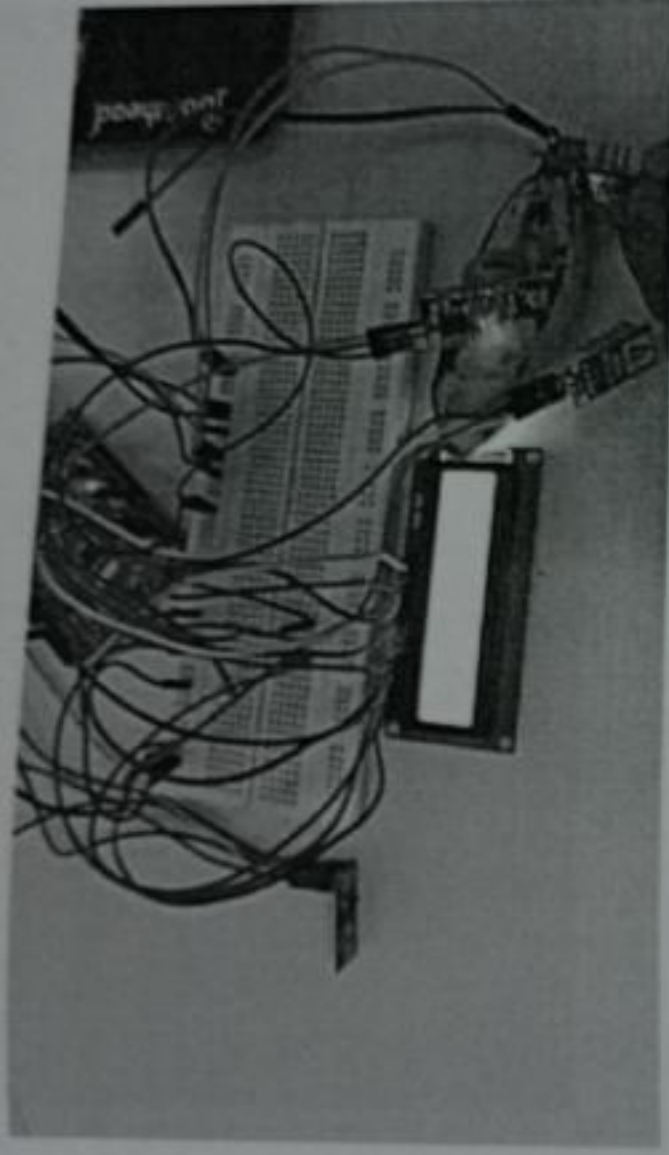
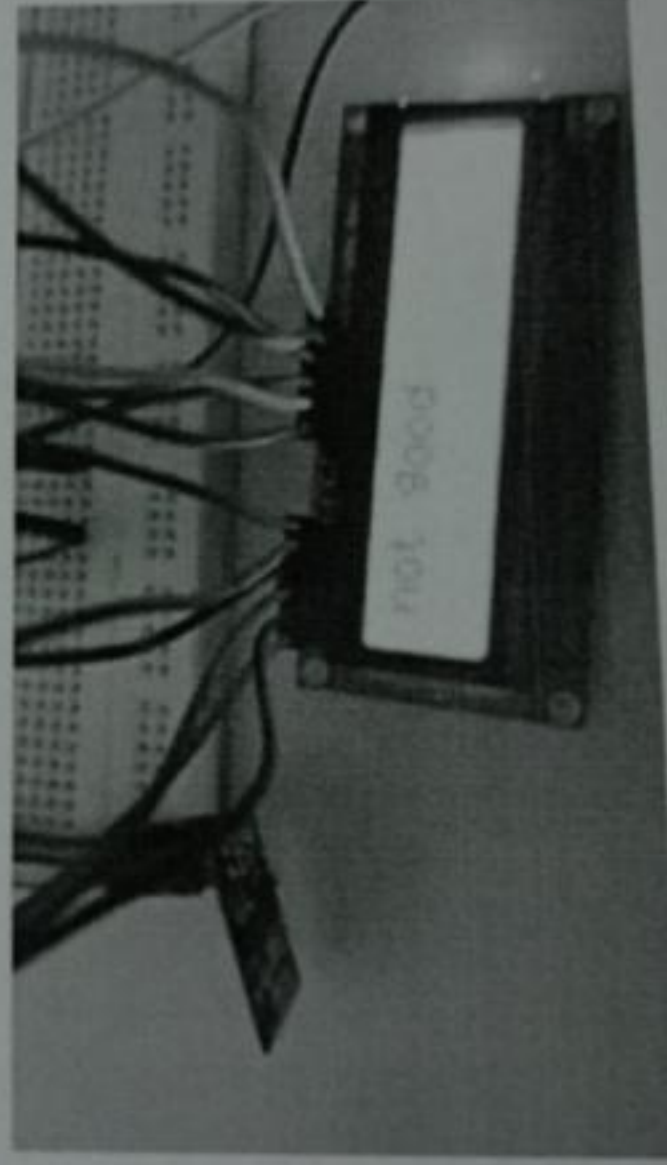


Fig A1: Working with sample



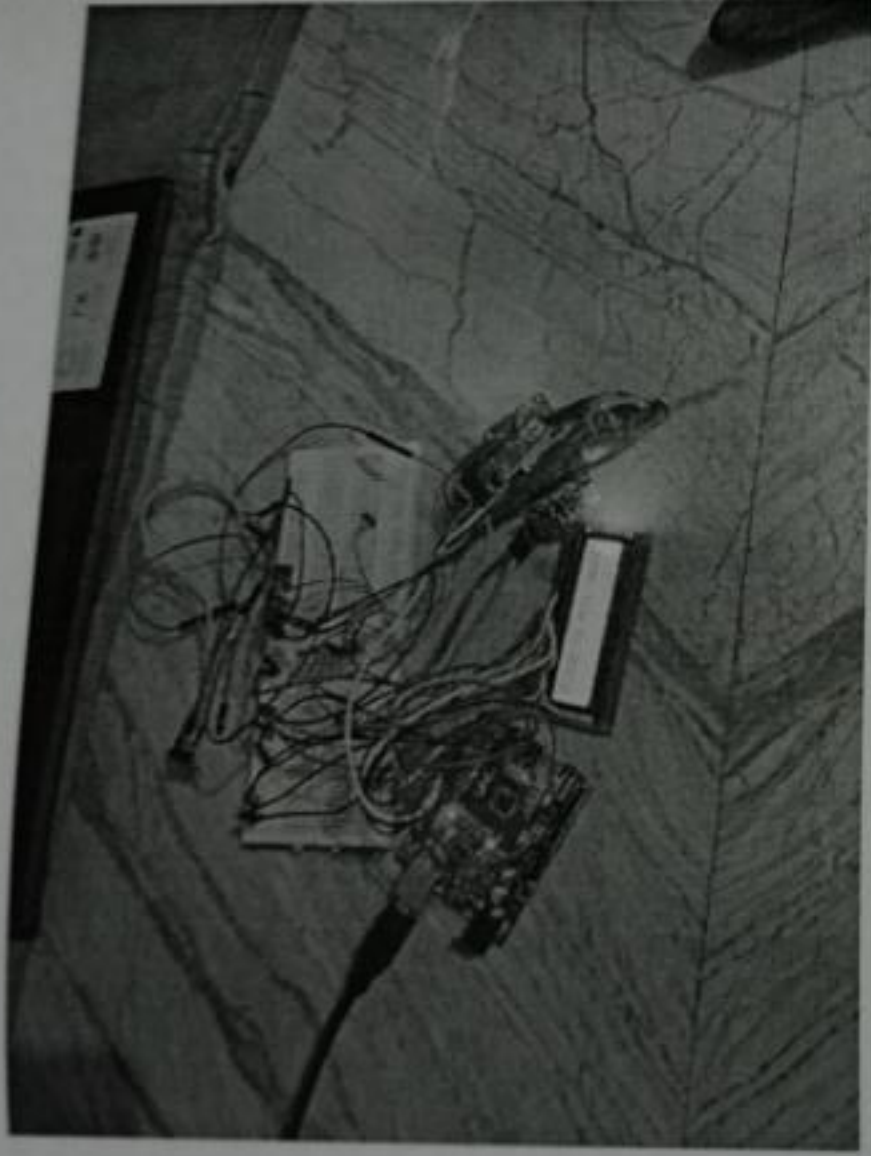


Fig A2: Output with spoiled food

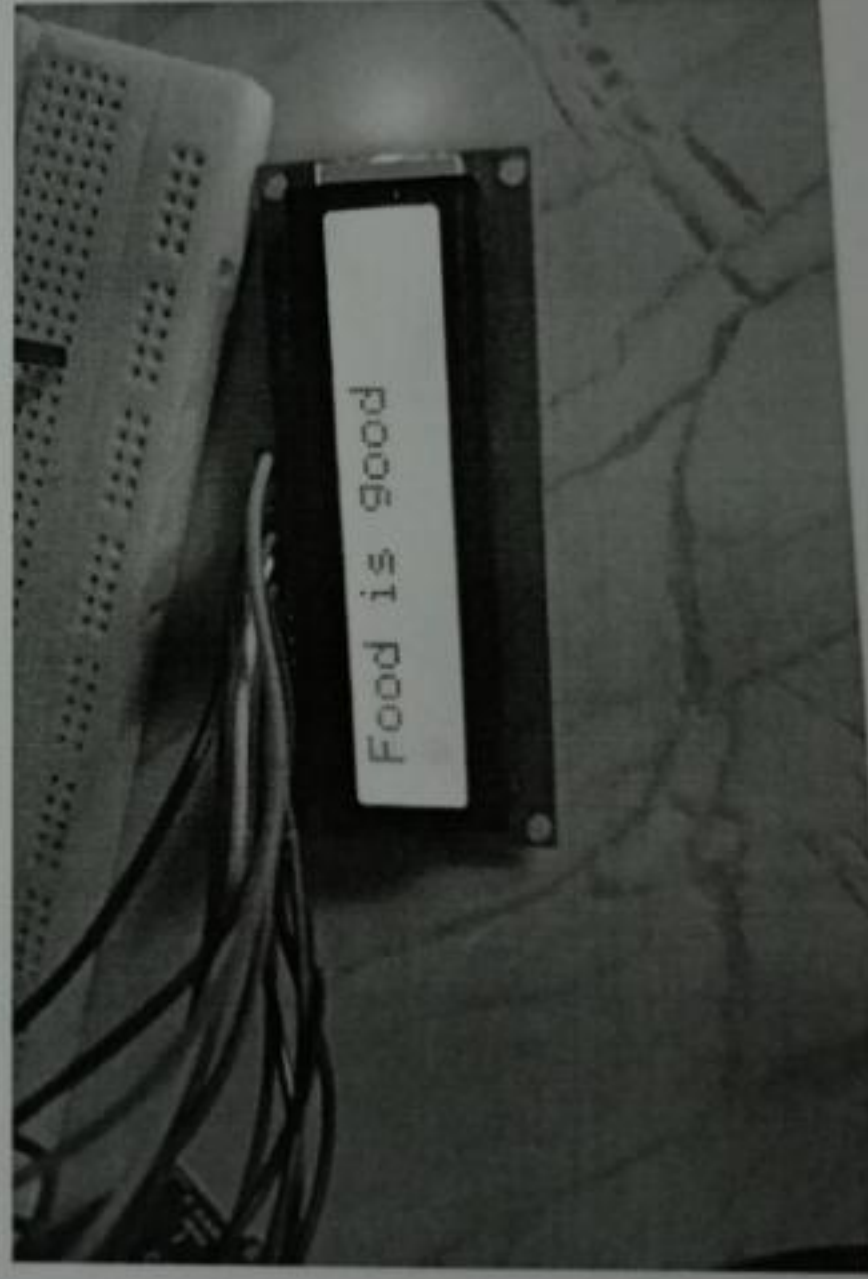




Fig A3: Output with Good food

B. CODE

```
//Program to
#include <SoftwareSerial.h>
#include <LiquidCrystal.h>
#include <dht.h> // include dht sensor library
LiquidCrystal lcd(10, 9, 5, 4, 3, 2);

dht DHT;

float t=0;
float h=0;

#define DHT11_PIN 8
#define LDR_PIN A1
#define MQ3_PIN A0

char data = 0;

int ldr_read = 0;
int gas_read = 0;

// replace with your channel's thingspeak API key
String apiKey = "[API KEY FROM THINGSPEAK]";

// connect 10 to TX of Serial USB
// connect 11 to RX of serial USB
SoftwareSerial ser(12,13); // RX, TX

void setup()
{
    // enable software serial
    ser.begin(9600);
    lcd.begin(16,2);
```

```
// pinMode(LDR_PIN, INPUT);  
// pinMode(MQ3_PIN, INPUT);  
  
lcd.setCursor(1,0);  
lcd.print("***SmarT Food***");  
lcd.setCursor(3,1);  
lcd.print("MonitorinG");  
Serial.begin(9600)  
  
// reset ESP8266 WiFi connection AT+CWMUX=1 AT+CWJAP  
ser.println("AT");  
delay(1000);  
ser.println("AT+GMR");  
delay(1000);  
ser.println("AT+CWMODE=3");  
delay(1000);  
ser.println("AT+RST");  
delay(5000);  
ser.println("AT+CIPMUX=1");  
delay(1000);  
String cmd="AT+CWJAP=[YOUR SSID],[PASSWORD]";  
ser.println(cmd);  
delay(1000);  
ser.println("AT+CIFSR");
```

```
    delay(1000);
  }
  // the loop
  void loop()
  {
    lcd.clear();

    ldr_read = analogRead(LDR_PIN);

    lcd.setCursor(0,0);
    lcd.print("LDR-");

    lcd.setCursor(4,0);
    lcd.print(ldr_read);

    lcd.setCursor(0,1);
    lcd.print("MQ3-");

    gas_read = analogRead(MQ3_PIN);

    lcd.setCursor(4,1);
    lcd.print(gas_read);

    int chk = DHT.read11(DHT11_PIN);

    Serial.print("Temperature = ");

    t = DHT.temperature;

    //lcd.clear();
```

```
lcd.setCursor(8,0);
```

```
lcd.print("Term-");
```

```
lcd.setCursor(12,0);
```

```
lcd.print(t);
```

```
Serial.println(t);
```

```
Serial.print("Humidity = ");
```

```
h = DHT.humidity;
```

```
lcd.setCursor(8,1);
```

```
lcd.print("Hum-");
```

```
lcd.setCursor(12,1);
```

```
lcd.print(h);
```

```
Serial.println(h);
```

```
esp_8266();
```

```
}
```

```
void esp_8266()
```

```
{
```

```
    // TCP connection AT+CIPSTART=4,"TCP","184.106.153.149",80
```

```
    String cmd = "AT+CIPSTART=4,\"TCP\"";
```

```
    cmd += "184.106.153.149"; // api.thingspeak.com
```

```
    cmd += " ,80";
```

```
    Ser.println(cmd);
```

```

Serial.println(cmd);
if (ser.find("Error"))
{
    Serial.println("AT+CIPSTART error");
    return;
}

// prepare GET string GET
https://api.thingspeak.com/update?api\_key=LHAG4NSIYJ5UWS6U&field1=0\r\n\r\n
String getStr = "GET /update?api_key=";

getStr += apiKey;

getStr += "&field1=";

getStr += String(t);

getStr += "&field2=";

getStr += String(h);

getStr += "&field3=";

getStr += String(ldr_read);

getStr += "&field4=";

getStr += String(gas_read);

getStr += "\r\n\r\n";

// send data length
cmd = "AT+CIPSEND=4,";

cmd += String(getStr.length());

ser.println(cmd);

Serial.println(cmd);

```

```
delay(1000);
```

```
ser.print(getStr);
```

```
Serial.println(getStr);
```

```
// thingspeak needs 15 sec delay between updates
```

```
delay(3000);
```

```
}
```

Intelligent Packing for Real time Monitoring of Food-Quality

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Abstract— Food packaging serves several purposes, including food preservation, shelf life extension, and upholding quality and safety requirements throughout manufacturing and storage. Intelligent food packaging, on the other hand, goes a step further by including sensors that continually check food quality throughout the supply chain. This enables food-borne hazards and waste to be analysed and reduced. Despite the fact that several sensing systems based on food quality indicators have been presented in recent years, practical implementations remain restricted. This paper critically analyses responsive technologies used for real-time monitoring of food quality and preservation state. It introduces food quality indicators and their relevance in the development of intelligent packaging.

Keywords:

Food quality, Monitoring, sensors, intelligent packing, food storage

1. INTRODUCTION

The World Health Organization has estimated that tainted food supplies lead to over 600 million cases of disease and 400,000 fatalities each year. Despite strict standards, food-borne infections continue to be a significant cause of illness and fatalities, making it crucial to monitor food quality in real-time. Traditionally, food packaging has used passive barriers to keep contaminants and moisture away from food products, but new technologies have emerged that allow for real-time monitoring of food quality indicators. These indicators include stability, nutritional value, consumer standards, and healthfulness. Optical intelligent packages are now being developed to provide instant quality insights to the food industry. However, challenges remain in integrating these technologies into existing packaging and ensuring their cost-effectiveness. With continued advancements, these technologies hold great potential for improving food safety and reducing food waste.

A. Scope of the Project

Much of the current work is focused in one major direction. Getting the quality of the food and to analyse whether the food is consumable or not.

B. Objective of the Project

The objective of our work is to Detect the quality of the food which is packed where it helps peoples to aware the quality of the food.

II. LITERATURE SURVEY

This section discusses the merits and demerits of the works which are done already related to the proposed work.

In [1] When conducting a literature review on the topic of food safety, it is important to first define your research question. This could involve exploring a specific aspect of food safety, such as the impact of packaging on foodborne illnesses. To gather relevant literature, search academic databases and government reports using relevant keywords related to your research question. Once you have identified potential sources, evaluate them by reviewing their abstracts and reading the full text of relevant sources. Analyze the sources you have collected, looking for common themes, findings, and limitations. Finally, synthesize the information you have gathered to draw conclusions and make recommendations for future research or policy.

In [2] The Estimating the Burden of Foodborne Diseases report is an online resource provided by the World Health Organization (WHO) that focuses on investigating and calculating the impact of foodborne diseases on global health. The report provides an overview of existing data on foodborne diseases and estimates of their consequences, including both morbidity and mortality rates.

In [3] Conclusion, auditing, food safety, and food quality standards are all crucial factors in the food industry. By implementing these standards, food companies can improve their processes, prevent foodborne illnesses, and produce high-quality products that meet the expectations of consumers.

The article titled "Application of Deep Learning in Food: A Review" by Zhou et al. provides a comprehensive review of the use of deep learning in the food industry. The authors provide a valuable review of the current state of deep learning in the food industry and suggest potential areas for future research and development. This article is a useful resource for researchers and practitioners interested in the applications of deep learning in the food industry [4].

Ali et al. suggest that supply chain integrity should be viewed as a strategic priority for food companies, as it can have a significant impact on their reputation, brand value, and financial performance. They conclude by calling for a multi-stakeholder approach that involves food producers, regulators, consumers, and other stakeholders in ensuring the safety and quality of the food supply chain [5].

In [6] Food fraud has become a major concern in the food industry due to its potential impact on public health, consumer trust, and the economy. As a result, there has been a growing interest in developing effective methods for

detecting and preventing food fraud. To this end, multivariate qualitative methods have emerged as a promising approach for identifying patterns and abnormalities in complex data sets. In this literature review, we provide an overview of the most relevant qualitative methods that are currently being used for food fraud detection. These methods include soft independent modeling of class analogy (SIMCA), principle component analysis (PCA), partial least squares discriminant analysis (PLS-DA), and Bayesian networks (BNs).

In recent years, there has been a growing interest in intelligent food packaging, which involves incorporating sensors and other technologies to monitor food quality and safety. This review highlights the significant potential of smart sensing technologies in the field of food packaging, and we discuss some of the challenges that must be addressed in order to fully realize this potential. We also provide some recommendations for future research in this area.

Dobrucka et al. [9] presents a comprehensive overview of the recent advancements and emerging trends in the area of smart and intelligent food packaging. The authors discuss the current challenges and opportunities in this field, including the need for enhanced product safety, longer shelf-life, and improved quality control. The article highlights the role of smart and intelligent packaging technologies in meeting these demands by incorporating functionalities such as moisture and oxygen barriers, antimicrobial agents, and temperature sensors. The authors also discuss the potential of these technologies to communicate important information, such as freshness indicators, to consumers [8].

In [9] The paper proposes a system that uses IoT sensors and machine learning to detect the freshness of food. The literature review discusses existing techniques and their limitations, highlighting the need for more efficient and reliable methods. The proposed system shows promise in reducing food wastage and improving food safety.

In [10] The paper proposes a fuzzy-based storage assignment system for packaged food warehousing that uses intelligent techniques for optimal storage assignment. The literature review discusses existing methods and their limitations, highlighting the need for a more efficient and flexible approach. The proposed system uses fuzzy logic to assign storage locations based on various factors and outperformed a rule-based system in experiments. The proposed system shows promise in improving the efficiency of packaged food warehousing.

In [11] The paper discusses the use of smart sensors for intelligent containers in the context of the Internet of Things (IoT). The literature review highlights the challenges of ensuring the quality and safety of goods during transportation and the need for real-time monitoring of environmental conditions. The proposed solution uses smart sensors to monitor environmental conditions during transportation and transmit the data to a central system for analysis. The paper also discusses the potential benefits of the proposed solution, such as reducing waste, improving product quality, and increasing efficiency in logistics and supply chain management.

In [12] The comprehensive literature review on global food losses and food waste. It covers the extent of food losses and waste across the food supply chain, the causes of food losses and waste, and potential solutions to address this issue. The authors also discuss the role of technology and innovation in addressing food losses and waste. Overall, the paper stresses the need for collaboration and sustainability considerations in food systems planning and policy-making.

In [13] A literature review on two underestimated threats in food transportation, mold and acceleration. It discusses the impact of mold and acceleration on food quality and safety, as well as the current methods for detection and prevention. The authors emphasize the importance of considering these threats in food transportation and highlight the need for research and collaboration among stakeholders in the food supply chain to ensure the safety and quality of food during transportation.

In [14] It discusses the need for decision support systems in M2M networks for efficient and safe transportation of goods, especially in domains such as logistics and food transportation. The authors propose using smart dynamic software components to enable decision support in M2M networks and demonstrate their effectiveness in a simulated food transportation scenario.

In [15] The paper explores the need for decision support systems in M2M networks for efficient and safe transportation of goods, particularly in logistics and food transportation. The authors propose using smart dynamic software components to facilitate decision support in M2M networks, demonstrating their effectiveness in a simulated food transportation scenario. The paper provides insights into the potential of M2M networks and highlights the need for efficient and safe transportation, offering an innovative approach with practical applications in various domains.

In [16] The warehouse storage policies in logistics, their challenges, and proposes a multi-objective assessment framework using fuzzy information axiom to handle uncertain and vague information. The framework is demonstrated to be effective in a case study, providing practical solutions for optimizing space utilization, accessibility, and cost-effectiveness. The paper by J. Wang, X. Ding, and B. Guo proposes a high precision food detection method using a deep object detection network. The authors discuss the limitations of traditional methods for food detection and provide an overview of the proposed method's architecture, dataset, and experimental results. They also provide a brief review of existing methods for food detection and highlight the need for more accurate and efficient approaches [17].

The paper by D. Pandey et al. proposes an object detection method using transfer learning with YOLOv4 for accurate detection of food items in Indian food platters. The authors explain the challenges in food detection and provide a detailed methodology and experimental results. They also briefly discuss the limitations of existing methods for food detection [18].

The paper by D. M. Chiang et al. proposes an adaptive approach for storage assignment in distribution centers using clustering techniques. The authors explain the limitations of traditional methods, provide a detailed explanation of their proposed approach, and present experimental results demonstrating its effectiveness. In terms of literature review, the authors highlight the importance of efficient storage assignment and briefly discuss existing methods, emphasizing the need for more effective approaches. Overall, the paper contributes to the literature by proposing an adaptive approach that can potentially improve efficiency and reduce costs [19].

C. Choy et al. proposes an RFID-based storage assignment system to improve the efficiency of order picking in warehouses. The authors explain the limitations of traditional methods and provide a detailed description of their proposed system, including the use of RFID tags, readers, and an assignment algorithm. Experimental results show the system's effectiveness. In terms of literature review, the authors highlight the potential benefits of RFID technology, briefly discuss existing research, and emphasize the novelty of their proposed system. Overall, the paper contributes to the literature by proposing an innovative system that can potentially improve warehouse operations [20].

In [21] "Towards Adaptive, Real-Time Monitoring of Food Quality Using Smart Sensors," Henrichs and Krupitzer propose a novel system for monitoring food quality in real-time using smart sensors. The system involves the continuous monitoring of various food quality parameters such as temperature and humidity, followed by the analysis of the data using machine learning algorithms. The authors suggest that this adaptive system could be a promising solution to overcome the current limitations of traditional food quality monitoring methods. However, the system is still in its developmental phase and requires further validation before its implementation in real-world scenarios.

In [22] paper "Characteristics and Determinants of Domestic Food Waste: A Representative Diary Study across Germany" published in Sustainability in 2020 presents a detailed examination of food waste in households in Germany. The study involved a representative survey of 1,008 households and collected data on the types of food waste, reasons for waste, and disposal methods used. Key findings indicate that meat and vegetables are the most commonly wasted food items, and households with more members tend to waste more food. The study also explores determinants of food waste, such as age, education, income, and household size. The paper emphasizes the need for research and policy interventions to reduce food waste and promote sustainability, which can help achieve global development goals.

In [23] "Can a Byte Improve Our Bite? An Analysis of Digital Twins in the Food Industry," published in the journal Sensors in 2022, explores the potential of digital twin technology in the food industry. The authors introduce digital twin technology and its possible benefits in different sectors, including the food industry. They present a case study of a

digital twin system implemented in a food production facility and discuss the various components of the system. The paper also examines the challenges and limitations of digital twin technology, such as data privacy concerns and the requirement for specialized expertise. The authors conclude that digital twin technology has the potential to improve food quality and safety and revolutionize food production. This analysis provides valuable insights into the potential applications and challenges of digital twin technology in the food industry, which can inform further research and development in this emerging field.

In [24] "Potential Chipless RFID Sensors for Food Packaging Applications: A Review" was published in the IEEE Sensors Journal in September 2020. It examines the potential use of chipless radio frequency identification (RFID) sensors in food packaging applications. The paper also discusses the challenges and limitations of chipless RFID technology and offers potential solutions to address these challenges. Overall, this review provides a comprehensive analysis of the potential use of chipless RFID sensors in food packaging applications and offers insights into the current state-of-the-art and future research directions in this area.

In [25] Article in the Sensors journal titled "Chipless-RFID: A Review and Recent Developments" provides an overview of the latest advancements and current state-of-the-art in the field of chipless radio frequency identification (RFID). The authors explain the different types of chipless RFID systems, their operating principles, advantages, and limitations, and examine their potential applications. The paper also covers recent advancements in antenna design, reader architecture, and signal processing techniques. It discusses the challenges and limitations of this technology and proposes potential solutions. Finally, the paper highlights current research trends and proposes potential future directions for further development.

III. PROPOSED ARCHITECTURE

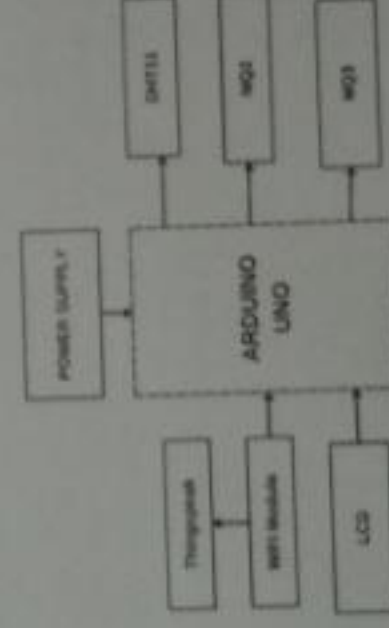


Fig. 1. System Architecture

The Internet of Things (IoT) is an emerging idea that involves linking devices to the internet utilizing sensors, actuators, and other identifying and sensing technologies to enable smart recognition, placement, tracing, and management. Intelligent sensor, wireless communication, and radio frequency identification (RFID) technologies are

is mentioned in the IoT sensing system. In order to create a safety and traceability system for handling perishable food, an Internet of Things is therefore possible.

1. METHODOLOGY

The project consists of sensors and Arduino as micro controller, Monitoring, Tracking, Controlling.

Proposes a system using Bluetooth Low Energy and IoT technology, to trace the food quality throughout the sanitation by using an electronic tag.

A. Arduino Uno board

The Arduino Uno is a micro controller board that uses the ATmega328P microprocessor. It is one of the most popular Arduino boards and is extensively utilized in a wide range of projects, from basic hobby projects to complicated industrial applications. The board contains 14 digital input/output pins, 6 analogue inputs, a quartz crystal with a frequency of 16 MHz, a USB connection, a power connector, an ICSP header, and a reset button. The Arduino Integrated Development Environment (IDE) is a simple and user-friendly platform for creating and uploading code to the board that may be used to programme it. The adaptability of the Arduino Uno board is one of its primary strengths.

It can be used to control various sensors, motors, and other electronic components, making it a popular choice for robotics projects, home automation systems, and interactive art installations. The board can also be easily connected to other devices and systems, such as smartphones, computers, and the internet, using various communication protocols and interfaces. Overall, the Arduino Uno board is a powerful and flexible tool for electronics enthusiasts and professionals alike, and its popularity is a testament to its reliability, ease of use, and versatility.

B. DHT11 Sensor The thermistor and capacitive humidity sensor make up the majority of this sensor. It transforms analogue data into a digital signal that displays temperature and humidity.

C. MQ3 Sensor

It is used to sense the presence of alcohol using SnO2 as the sensitive material. The concentration of alcohol gas in the environment increases the conductivity of the sensing material, using which the alcohol presence in the environment can be determined.

D. MQ2 Sensor

The presence of gas or smoke is detected by the MQ2 Sensor. It detects smoke in the surroundings by altering the resistance of the sensor material.

E. ESP8266 Wifi Module

It is a system on chip (SoC) module preprogrammed with a TCP/IP protocol stack that allows the microcontroller to connect to a Wi-Fi network. It is typically utilized for various IoT applications.

F. Thingspeak

ThingSpeak is an Internet of Things (IoT) analytics platform that allows users to collect, analyze, and visualize data from sensors or other IoT devices. It provides a cloud-based platform that enables users to store and analyze their IoT data, as well as build applications based on that data. ThingSpeak is a powerful tool for collecting and analyzing data from IoT devices, allowing users to gain insights and make data-driven decisions based on their data.

The three sensors in this project - DHT11, MQ2, and MQ3 - are all capable of detecting certain properties of food that can help to identify when it has spoiled and is no longer safe to eat.

The DHT11 sensor can measure both temperature and humidity levels in the surrounding environment. When food spoils, it often undergoes a change in temperature and humidity due to the growth of bacteria and other microorganisms. By monitoring these changes with the DHT11 sensor, it may be possible to detect when food has spoiled.

The MQ2 sensor is specifically designed to detect the presence of methane gas, which is a byproduct of the decomposition of organic matter. As food spoils, it releases gases like methane, which can be detected by the MQ2 sensor. By monitoring the methane content in food, it may be possible to determine if the food has spoiled and is no longer safe to eat.

The MQ3 sensor, on the other hand, is designed to detect the presence of alcohol vapors. While not all spoiled food will contain alcohol, some types of spoilage can produce alcohol as a byproduct. By monitoring the alcohol content in food with the MQ3 sensor, it may be possible to detect spoilage and determine if the food is safe to eat.

Then the data is shared to Thingspeak through a Wi-Fi module, then using Thingspeak we can show the visualization and monitor the sensors.

Overall, by combining the data from all three sensors, it may be possible to identify a pattern of changes that occur when food spoils, such as an increase in humidity, methane content, or alcohol content. By detecting these changes early on, it may be possible to prevent the consumption of spoiled food and reduce the risk of foodborne illness.

IV. EXPERIMENTAL RESULT

A. Working of proposed model

Food packaging covers the present role of preserving food, thereby improving shelf life, while maintaining maximum quality and safety both throughout the manufacturing process

ed while the food is kept. Intelligent food packaging depends on the capabilities of traditional packaging by adding the capacity to continually monitor food quality throughout the supply chain in order to analyse and reduce the growth in foodborne disease and food waste. Several sensing systems based on various food quality indices have lately been developed for this purpose, but commercial implementation remains problematic. This article provides a complete review of the responsive systems used in real-time monitoring of food quality and preservation conditions. First, indicators of food quality are briefly explained, followed by their application.

Screenshots:



Fig 2: Working with sample



Fig 3: Output with spoiled food



Fig 4: Output with Good food

V. CONCLUSION

The market for active, intelligent, and smart food packaging is quickly expanding, with more than USD 38 billion in packages expected to be supplied in 2020, and a predicted value of USD 50 billion by 2026. These approaches, however, are not commonly employed due to their high cost and poor integration into current programmes.

Current advances in chemistry, microelectronics, materials science, engineering, biotechnology, and nanotechnology provide prospective answers for developing and manufacturing novel packaging solutions that are less expensive and more appropriate for large-scale applications. Colorimetric sensor-based optical systems, for example, show promise for testing food quality at a cheaper cost and without the need for costly equipment. By integrating such sensors with RFID, sensitivity may be increased to improve safety, quality, and efficiency.

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