



Smart Onion Storage System (StorEdge): An IoT-Based Approach for Intelligent Post-Harvest Management

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Abstract— Post-harvest losses in onions represent a significant challenge in agricultural supply chains, particularly in developing countries like India where storage infrastructure is often inadequate. These losses are primarily caused by uncontrolled environmental conditions such as high relative humidity, temperature fluctuations, and insufficient ventilation, which accelerate spoilage, sprouting, and microbial growth. Addressing these issues is essential to improve food preservation, reduce economic losses, and enhance farmer income. This paper presents StorEdge, an Internet of Things (IoT)-based smart onion storage system designed to monitor and regulate environmental conditions in real time. The system integrates temperature and humidity sensors with a microcontroller-based control unit that continuously evaluates storage parameters. A threshold-based automated control mechanism activates ventilation systems when environmental conditions deviate from optimal ranges, thereby maintaining a stable storage environment. The proposed system is designed to be cost-effective, scalable, and suitable for deployment in rural and semi-urban regions. Experimental observations demonstrate that StorEdge significantly reduces moisture accumulation, improves air circulation, and extends the shelf life of onions compared to traditional storage methods. The study highlights the potential of integrating IoT and automation in post-harvest management to improve agricultural efficiency and sustainability.

Keywords— IoT, Smart Storage, Onion Preservation, Post-Harvest Loss, Embedded Systems, Temperature Control, Humidity Control.

I. INTRODUCTION

Agriculture is a fundamental component of the Indian economy, and onions are one of the most widely produced and consumed crops across the country. Despite large-scale production, a considerable portion of harvested onions is lost during the post-harvest stage due to inadequate storage facilities and lack of proper environmental control. These losses not only affect farmers' income but also disrupt market supply and price stability. Onions are highly sensitive to environmental conditions during storage. Factors such as temperature, humidity, and ventilation play a critical role in determining their shelf life and quality. High humidity promotes fungal growth and rotting, while temperature fluctuations can lead to sprouting and dehydration. Traditional storage methods, such as open-air storage or naturally ventilated sheds, rely heavily on external environmental conditions and lack the ability to monitor or regulate these parameters effectively. With the

advancement of Internet of Things (IoT) and embedded systems, smart agricultural solutions have emerged as a promising approach to address such challenges. Sensor-based monitoring systems enable real-time data collection, while automated control mechanisms allow dynamic adjustment of environmental conditions. Although these technologies have been widely applied in crop cultivation and greenhouse systems, their use in post-harvest storage remains limited. To address this gap, this paper proposes StorEdge, a smart onion storage system that utilizes IoT technology to monitor and control storage conditions in real time. The system aims to reduce post-harvest losses, improve storage efficiency, and provide a cost-effective solution suitable for rural deployment.

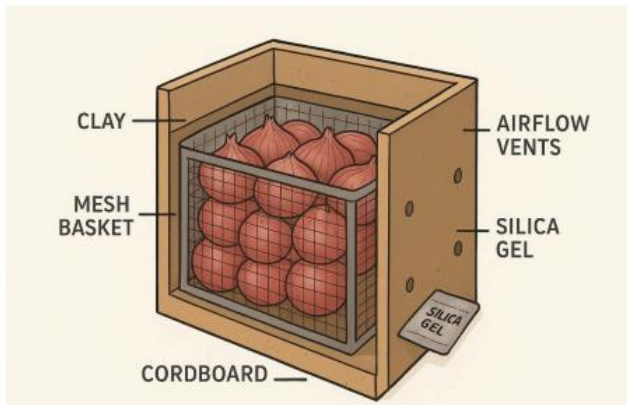


Fig:1 Proposed Smart Onion Storage Unit with Controlled Airflow, Moisture Absorption, and Mesh-Based Ventilation System.

II. PROBLEM STATEMENT

Despite advancements in agricultural production, post-harvest storage of onions remains a major challenge due to the lack of efficient and controlled storage systems. Traditional storage methods are unable to maintain the optimal environmental conditions required for preserving onion quality over extended periods.

One of the primary issues is excessive humidity, which leads to the growth of fungi and bacteria, causing rotting and decay. Additionally, temperature variations contribute to sprouting and moisture loss, further reducing the quality and market value of onions. Poor ventilation exacerbates these problems by trapping heat and moisture inside the storage structure.



Fig:2 Traditional Onion Storage Structure Using Naturally Ventilated Storage Shed

III. METHODOLOGY

The primary objective of this research is to design and develop an intelligent onion storage system that minimizes post-harvest losses through real-time monitoring and automated control of environmental conditions. The system aims to continuously monitor critical parameters such as temperature and humidity using appropriate sensors and process this data using a microcontroller. Based on predefined threshold values, the system automatically activates ventilation mechanisms to maintain optimal storage conditions. Another key objective is to ensure that

the system remains cost-effective and scalable so that it can be easily adopted by farmers, particularly in rural areas. Additionally, the research seeks to demonstrate the practical application of IoT and embedded systems in post-harvest management and contribute to improving agricultural sustainability and efficiency.

IV. LITERATURE REVIEW

Post-harvest storage has been a subject of extensive research, particularly in the context of reducing agricultural losses. Traditional onion storage techniques primarily involve the use of ventilated structures, raised platforms, and natural airflow systems. While these methods are cost-effective, they are highly dependent on ambient environmental conditions and lack precision in controlling storage parameters. Several studies have highlighted the importance of maintaining low humidity and stable temperature conditions to prevent spoilage and extend shelf life. However, conventional storage systems do not provide mechanisms for continuous monitoring or automated control, leading to inefficiencies and losses. In recent years, the application of IoT in agriculture has gained significant attention. Sensor-based systems have been successfully used in greenhouse management to monitor temperature, humidity, and soil conditions. These systems enable real-time data collection and automated responses, improving overall efficiency and productivity.

V. PROPOSED SYSTEM (STOREDGE)

A. System Overview

StorEdge is an IoT-based smart storage system designed to maintain optimal environmental conditions for onion preservation. The system operates as a closed-loop control system, where environmental parameters are continuously monitored and adjusted automatically to ensure stability. The system is composed of three main layers: sensing, processing, and actuation. The sensing layer collects real-time data, the processing layer analyzes the data and makes decisions, and the actuation layer performs necessary actions to regulate conditions.

B. System Components

The system utilizes temperature and humidity sensors such as DHT11 or DHT22 to monitor environmental conditions inside the storage unit. A microcontroller, such as Arduino or NodeMCU, processes the sensor data and executes control logic. The ventilation system, consisting of fans or exhaust units, is used to regulate airflow and remove excess heat and moisture. An optional communication module can be integrated to enable remote monitoring through cloud platforms or mobile applications. The entire system is powered by a stable power supply, which can be further enhanced using renewable energy sources.

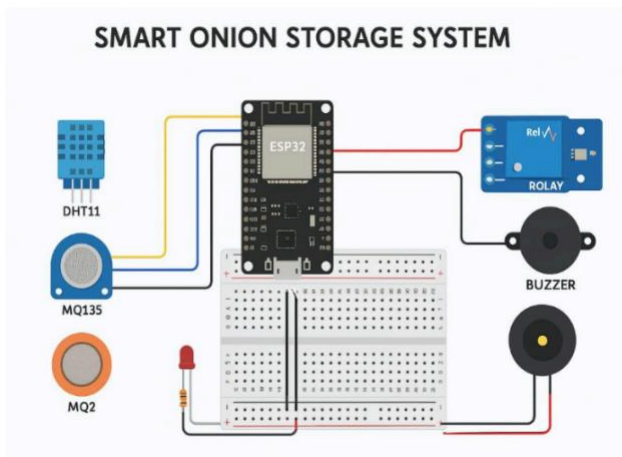


Fig:3 Circuit Diagram of the StorEdge System Showing Sensor and Microcontroller Connections

C. Working Principle

The working of StorEdge is based on continuous monitoring and automated control. Sensors collect real-time data on temperature and humidity, which is then transmitted to the microcontroller. The microcontroller compares these values with predefined threshold limits. If the humidity level exceeds the safe range, the system activates the ventilation system to reduce moisture. Similarly, if the temperature rises above the optimal range, airflow is increased to cool the environment. Once the conditions return to normal levels, the system automatically turns off the actuators. This closed-loop mechanism ensures that the storage environment remains stable without requiring manual intervention.

D. System Architecture

The architecture of StorEdge consists of an input layer (sensors), a processing layer (microcontroller), and an output layer (actuators). An optional communication layer enables IoT-based monitoring and control. This structured design ensures efficient operation and scalability of the system.

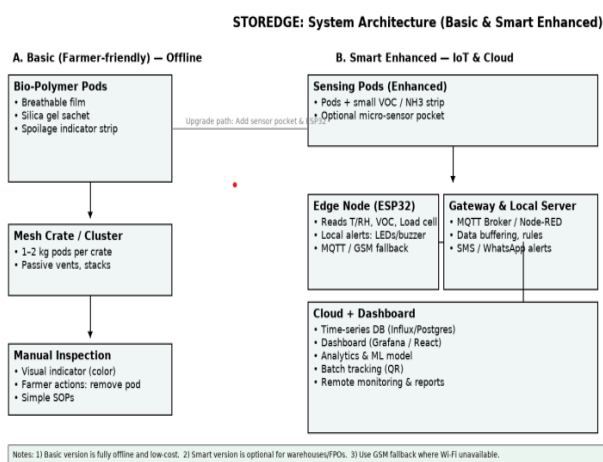


Fig: 4 System Architecture of StorEdge (Basic and IoT-Enabled Model)

VI. METHODOLOGY

The development of the StorEdge system follows a systematic approach that includes requirement analysis, hardware design, software implementation, and performance evaluation. Initially, the optimal storage conditions for onions were identified based on agricultural studies. Suitable hardware components were then selected to meet these requirements. The system was designed and assembled using sensors, microcontrollers, and actuators. The software was developed using embedded programming to implement the control logic. The system was then integrated and tested under different environmental conditions to evaluate its performance. Data collected during testing was analyzed to assess the effectiveness of the system.

VII. RESULTS AND DISCUSSION

The performance of the StorEdge system was evaluated through experimental testing. The results indicate that the system effectively maintains temperature and humidity within the desired range. The automated ventilation system successfully reduced moisture accumulation and improved air circulation inside the storage unit. Compared to traditional storage methods, the system demonstrated a significant reduction in spoilage rates and improved shelf life of onions. The real-time monitoring and control capabilities of the system ensure quick response to environmental changes, making it more reliable and efficient than conventional methods. However, further testing on a larger scale is required to validate its performance in real-world conditions.

A. Advantages and Limitations

The proposed system offers several advantages, including reduced post-harvest losses, automated operation, and improved storage efficiency. It is cost-effective and can be easily scaled for larger storage units. The system also reduces dependency on manual monitoring, thereby minimizing human error. However, the system has certain limitations. The initial setup cost may be a barrier for some farmers, and continuous operation requires a reliable power supply. Additionally, the system requires periodic maintenance to ensure proper functioning of sensors and electronic components.



Fig:5 SWOT Analysis of StorEdge System

VIII. CONCLUSION

This paper presented StorEdge, a smart onion storage system that utilizes IoT and automation to reduce post-harvest losses. The system effectively monitors and controls environmental conditions, resulting in improved storage efficiency and reduced spoilage. The proposed solution is cost-effective, scalable, and suitable for practical implementation. It demonstrates the potential of smart technologies in transforming post-harvest management and improving agricultural sustainability.

Future Scope

The StorEdge system can be further enhanced by integrating advanced technologies to improve its functionality and efficiency. One of the key areas of development is the incorporation of mobile and web-based applications, which would enable remote monitoring and control of the system. Cloud-based data storage and analytics can be implemented to analyze long-term trends and optimize storage conditions. The integration of artificial intelligence and machine learning can enable predictive analysis, allowing the system to anticipate unfavorable conditions and take preventive actions. The use of renewable energy sources such as solar power can make the system more sustainable and suitable for rural areas. Additionally, advanced sensors can be incorporated to improve accuracy and detect spoilage at an early stage.

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