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THE DEVELOPMENT OF A REAL-TIME MONITORING SYSTEM USING IoT SENSOR TECHNOLOGY

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ABSTRACT

This study developed an IoT-based monitoring system for cold storage of agricultural products. Using temperature-humidity, CO_2, and ethylene sensors with Raspberry Pi, real-time data were collected and analyzed. Field tests showed stable monitoring of temperature (3~8 °C), humidity (77~92%), and CO_2 (450~1400 ppm), while no ethylene was detected. The system demonstrated reliable performance and potential to improve quality control and efficiency in post-harvest storage.

Keywords: IoT, Sensors, Real-time, Database, Raspberry Pi

INTRODUCTION

The quality and shelf life of agricultural products depend on post-harvest storage conditions, especially temperature, humidity, and gases like CO_2 and C_2H_4. Poor control of these factors speeds up spoilage and lowers market value.Traditional monitoring methods often rely on periodic manual sampling, using handheld devices or spot checks that measure only a few parameters such as temperature or humidity. These approaches provide limited data coverage and low temporal resolution, making it difficult to detect rapid or localized environmental changes necessary for effective storage management. IoT technologies enable real-time, multi-parameter sensing and remote data handling (Ramírez-Faz et al., 2020; Moon et al., 2015).

The objective of this research is to develop a reliable IoT-based monitoring system for agricultural cold storage that provides continuous, multi-parameter environmental data to support data-driven storage management strategies and improve post-harvest quality control.

MATERIALS AND METHODS

The developed system configuration is shown in Figure 1. The system used commercial sensors: DHT22 for temperature (-40~80°C, ±0.5°C) and humidity (0~100%, ±2%), SH-300-DS for CO_2 (0~25000ppm, ±3%), and ME03-C_2H_4 for ethylene (0~100ppm, ±0.1ppm). Sensors were factory-calibrated and validated against references. Data were collected every 10 seconds via Raspberry Pi Zero 2W and sent over Wi-Fi using WebSocket to a Raspberry Pi 4 for storage and visualization. Laboratory tests included three repeats measuring CO_2 (avg. 2,800ppm at 200s) and ethylene (avg. 8.6ppm at 1,200s) compared to reference values (CO_2: 3,100ppm; ethylene: 8.7ppm). CO_2 agreed within 10%, while ethylene showed a discrepancy over 20ppm, likely due to environmental effects. Performance was assessed by accuracy, response time, and repeatability. The system was then deployed for continuous monitoring in a commercial cold storage.

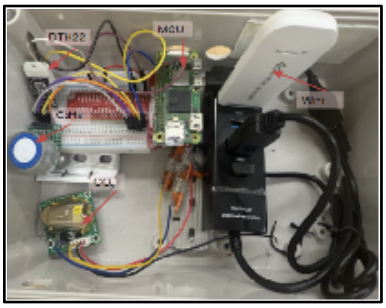

Fig.1. Developed IoT devices

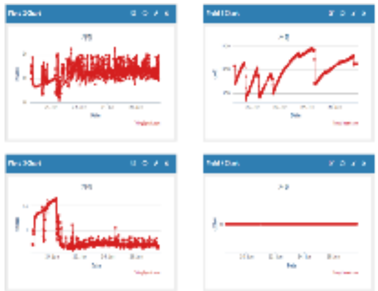

Fig.2. Data collected from the APC

RESULTS & DISCUSSION

The system provided uninterrupted real-time monitoring. The measured data is shown in Figure 2. CO_2 averaged 860 ± 210 ppm (450~1400 ppm), temperature 5.2 ± 1.1 °C (3~8 °C), and humidity 84.5 ± 4.6% (77~92%). Ethylene averaged 8.6 ppm in lab tests but was often below detection limits in commercial storage. Validation with reference sensors (WASP-XM, AR8200) confirmed high accuracy. Similar findings have been reported for gas sensor applications in fruit storage (Yin et al., 2023). CO_2 fluctuations corresponded to door openings and defrost cycles, indicating acceptable storage conditions. The integrated ethylene monitoring offers practical benefits, though further long-term validation is needed.

CONCLUSIONS

This study demonstrated a cost-effective IoT system for real-time monitoring of temperature, humidity, CO_2, and C_2H_4 in cold storage. While specific cost analyses are pending, the system offers potential economic advantages over conventional methods by reducing spoilage and labor. It reliably tracked environmental changes with accuracy confirmed against reference instruments. Although tested in a commercial cold storage, further validation across diverse environments is needed. Future work will enhance data analytics and system integration with automated controls for optimized storage management.

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