

IoT-Based Monitoring Prototype for Food Production Conditions and Batch Traceability in Indonesian SMEs

Muhammad Jufri ^{1*}, Hendra Maulana ², Sriwanti Belani ³, Iim Al Imron ⁴, Graceilla Kristia Sheraphim Budiono ⁵, Deosa Putra Caniago ⁶, Putri Desmitha Natasya ⁷

^{1*,7} Digital Business Study Program, Faculty of the School of Business Economics and Management, Institut Teknologi Batam, Batam City, Riau Islands Province, Indonesia

² Digital Business Study Program, Faculty of Computer Science, Universitas Pembangunan Nasional Veteran Jawa Timur, City of Surabaya, East Java Province, Indonesia

³ Digital Business Study Program, Faculty of Economics and Business, Universitas Muhammadiyah Luwuk Banggai, Banggai Regency, Central Sulawesi Province, Indonesia

⁴ Digital Business Study Program, Faculty of Business and Social Sciences, Universitas Bhakti Husada Indonesia, Kuningan Regency, West Java Province, Indonesia

⁵ Digital Business Study Program, Faculty of Legal and Business Technology, Universitas Sugeng Hartono, Sukoharjo Regency, Central Java Province, Indonesia

⁶ Computer Engineering Study Program, Faculty of Information Technology, Institut Teknologi Batam, Batam City, Riau Islands Province, Indonesia

Email: jufri@iteba.ac.id ^{1*}, hendra.maulana.if@upnjatim.ac.id ², sriwantibisdig08@gmail.com ³, iimalimron@gmail.com ⁴, graceillas95@gmail.com ⁵, deosa@iteba.ac.id ⁶, 2432011@student.iteba.ac.id ⁷

Article history:

Received September 8, 2026

Revised October 26, 2026

Accepted October 31, 2026

Abstract

Food small and medium enterprises (SMEs), including Indonesian micro, small, and medium enterprises (MSMES), need practical ways to document production conditions and trace production batches. This study presents an IoT-based monitoring prototype that integrates temperature and humidity sensing, a microcontroller, cloud data storage, a mobile dashboard, and QR-based batch identification. The prototype is intended to display frying-process temperature, production-area humidity, cold-storage readings, production duration, and a preliminary operational risk indicator. The current evaluation is limited to prototype-level functional observation and partial screenshots/data; a complete calibrated sensor study, communication reliability test, latency measurement, and multi-batch field evaluation have not yet been completed. Therefore, the present results demonstrate the system concept and interface workflow rather than validated improvements in food safety or recording accuracy. The study contributes an integrated monitoring design for MSMES food-production settings and identifies the additional validation needed before operational deployment.

Keywords:

Food Safety Monitoring; Internet of Things; Production Traceability; Smart Kitchen; MSMES.

1. INTRODUCTION

The rapid advancement of digital technology has influenced industrial processes, including food production. Internet of Things (IoT) systems connect sensors and computing devices to collect and transmit measurements for monitoring and analysis (Domínguez-Bolaño et al., 2022; Hamdan et al., 2020). For Indonesian micro, small, and medium enterprises (MSMES), accessible digital monitoring may help organize production records and make environmental observations more systematic. However, the present study does not assume that a monitoring dashboard by itself guarantees food safety; sensor readings must be interpreted in relation to the product, process, and applicable food-safety requirements (Domínguez-Bolaño et al., 2022; Hamdan et al., 2020; Bouzembrak et al., 2019; Popa et al., 2019)

Food safety monitoring requires attention to process conditions and storage temperatures because unsuitable conditions may contribute to quality deterioration or microbial growth. Temperature and humidity readings can provide useful operational information, but they are not direct measurements of microbial

contamination or overall hygiene. Accordingly, the prototype described here should be understood as a tool for recording selected environmental indicators, not as a substitute for hazard analysis, sanitation procedures, or microbiological testing (McMeekin et al., 1997; De Silvestri et al., 2018; da Costa et al., 2023; Aguiar et al., 2022)

Production traceability supports the retrieval of information about raw materials, processing conditions, and individual production batches. IoT-enabled monitoring and digital identification can complement one another by associating recorded process observations with a batch record (Visconti et al., 2020; Li et al., 2024). In this study, QR codes are used as identifiers that link a production batch to its stored digital record; the QR code itself does not independently verify food safety or product authenticity (Li et al., 2024; Visconti et al., 2020; Protopappas et al., 2025; Shi et al., 2019)

A mobile interface can make recorded data easier to inspect and may help operators notice changes in monitored conditions. In the proposed prototype, the dashboard and historical graphs are intended to support observation of available sensor readings. Because the current testing is limited, the study does not claim a measured improvement in decision speed or production-recording accuracy (Saini et al., 2020; Aghenta & Iqbal, 2019)

Historical sensor records can be examined for trends and unusual readings, provided that the data quality and anomaly criteria are defined. In this prototype, historical visualization is a basic monitoring feature; predictive capability and validated anomaly detection are outside the scope of the current evidence. Cold-storage readings also need to be assessed against requirements appropriate to the particular food being stored, rather than a universal temperature range (Al-Amri et al., 2021; Rassam et al., 2013; Ramirez et al., 2020; Urbano et al., 2020)

QR-based traceability can provide a convenient access point to digital batch information (Ausawanetmanee et al., 2024; Li et al., 2024). Nevertheless, the research gap should be stated cautiously: this study does not establish that all existing systems are limited to temperature monitoring. Instead, it addresses a practical design objective—bringing selected temperature and humidity observations, production-duration records, a preliminary risk indicator, and QR-linked batch records into one prototype interface. The Indonesian MSMES context motivates the emphasis on an integrated and relatively accessible design, while formal compliance with applicable BPOM, SNI, Codex, or HACCP requirements must be assessed separately for each implementation (Ausawanetmanee et al., 2024; Li et al., 2024)

The objective of this study is to design an IoT-based monitoring prototype that brings selected food-production environmental readings and QR-based batch records into a mobile interface for Indonesian MSMES. The intended contributions are: (1) a layered prototype architecture integrating sensors, a microcontroller, cloud storage, and a mobile dashboard; (2) a QR-linked batch-record workflow; and (3) a preliminary operational risk indicator whose weighting, thresholds, and relationship to actual hygiene outcomes require further validation. The present paper reports a prototype design and limited functional observations; it does not claim validated food-safety performance or quantified improvements over manual recording.

2. RESEARCH METHOD

This study follows a prototype-development approach involving system architecture design, hardware and software integration, and preliminary functional observation. The prototype combines temperature and humidity sensing, a microcontroller, cloud-based data storage, a mobile monitoring interface, and QR-based batch identification. The available evidence consists of partial sensor data and interface screenshots. A complete experimental protocol—including the deployment site, testing duration, number of batches, reference-instrument calibration, communication reliability, latency, and QR scan success rate—was not documented in the materials available for this revision. These items are therefore treated as validation requirements rather than reported results.

2.1. Research Framework

The research framework describes the systematic stages carried out in this study, starting from problem identification to system implementation and evaluation. This framework ensures that the development of the Smart Kitchen monitoring system follows a structured research process. The research process begins with identifying the problems faced by food SMEs, particularly related to manual monitoring of production parameters such as frying temperature, environmental humidity, and production documentation. Based on these challenges, an IoT-based monitoring system was designed to improve production monitoring and data recording.

The next stage involves system architecture design, including the integration of sensors, microcontrollers, cloud databases, and mobile applications. The system is then implemented and tested to evaluate its performance in monitoring environmental parameters and production processes. The research framework used in this study is summarized in Table 1.

Table 1. Research Framework of Smart Kitchen Monitoring System

Stage	Description
Problem Identification	Identifying monitoring challenges in food SME production environments
Literature Study	Reviewing IoT monitoring systems and food safety monitoring technologies
System Design	Designing system architecture including sensors, microcontroller, and application
Hardware Development	Integrating temperature and humidity sensors with IoT devices
Software Development	Developing mobile monitoring application and cloud database
System Implementation	Deploying the monitoring system in the production environment
System Evaluation	Testing system functionality, sensor accuracy, and monitoring performance

The overall research process can also be illustrated using a research workflow diagram.

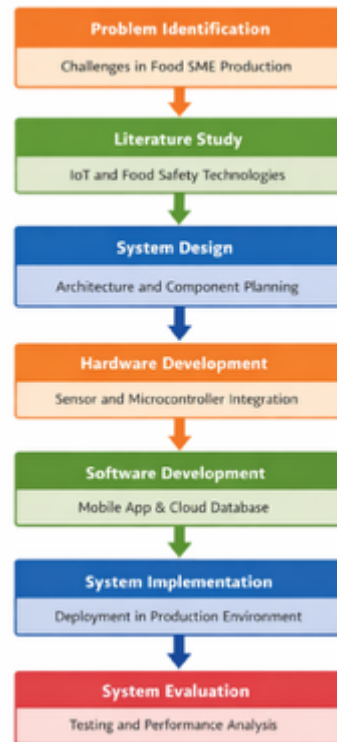


Figure 1. Research Framework of Smart Kitchen Monitoring System

2.2. System Architecture

The Smart Kitchen monitoring system is designed using a layered IoT architecture to enable efficient data acquisition, processing, and visualization. The system architecture consists of four main layers: the sensor layer, edge computing layer, cloud platform layer, and application layer.

- The sensor layer collects environmental data from the production area, including frying temperature, environmental humidity, and cold storage temperature. These sensors continuously measure environmental parameters and transmit the data to the microcontroller.
- The edge computing layer processes sensor data locally using a microcontroller. This layer performs preliminary data filtering and prepares the data for transmission to the cloud server.
- The cloud platform layer stores collected data in a centralized database that enables historical data storage and analysis.
- The application layer provides a mobile-based monitoring interface that displays real-time production data, historical graphs, and system alerts.

The system architecture enables continuous monitoring of food production environments while providing data-driven insights for production management.

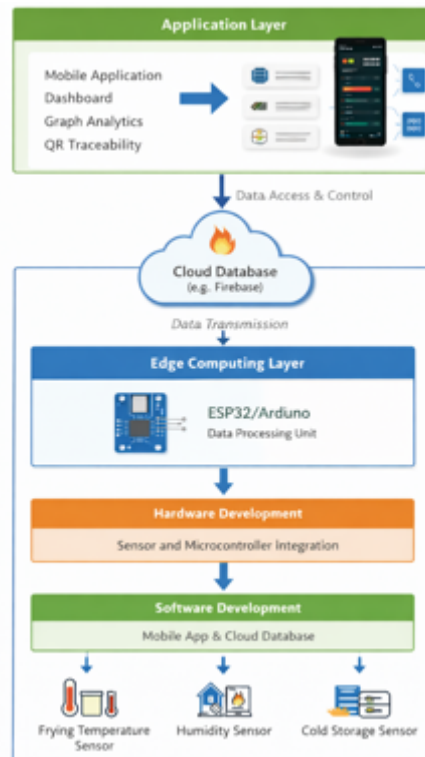


Figure 2. IoT-Based Smart Kitchen System Architecture

2.3. Hardware Design

The hardware subsystem is designed to collect selected measurements from the food-production environment. The component table identifies candidate components described in the prototype documentation. The exact installed component and firmware configuration should be confirmed against the physical prototype before the final submission; alternatives listed in the table must not be interpreted as components tested simultaneously.

Table 2. Hardware and Software Components of Smart Kitchen Monitoring System

Component	Type	Function
Microcontroller	ESP32 / Arduino	Processes sensor data and manages IoT communication
Temperature Sensor	DS18B20 / Thermocouple	Measures frying oil temperature and cold storage temperature
Humidity Sensor	DHT22	Measures production room humidity
Communication Module	WiFi Module	Sends data to cloud database
Cloud Database	Firebase / Cloud Server	Stores monitoring data
Mobile Application	Android Application	Displays dashboard monitoring system

The hardware components are integrated into an IoT monitoring node installed in the food production environment.

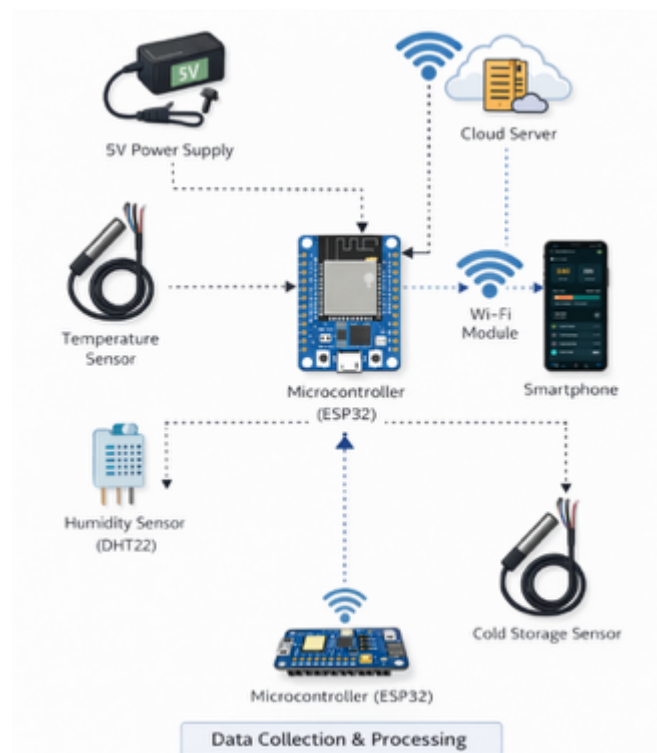


Figure 3. Hardware Configuration of Smart Kitchen Monitoring Device

2.4. Software System Design

The software system consists of a mobile monitoring application integrated with a cloud database. The application provides real-time visualization of environmental parameters and production activities. The mobile application includes several functional modules:

- Dashboard Monitoring Module.** Displays real-time production data such as temperature, humidity, hygiene index, and production timer.
- Graph Analytics Module.** Provides historical data visualization for analyzing trends in production conditions.
- Hygiene Log Module.** Records events related to abnormal environmental conditions such as high temperature or humidity fluctuations.
- Cold Storage Monitoring Module.** Displays refrigerator and freezer temperature in real time.
- QR Traceability Module.** Allows production batches to be tracked through QR code identification.



Figure 4. Mobile Application Interface of Smart Kitchen Monitoring System

2.5. Hygiene Index Algorithm

The initial manuscript described a Hygiene Index combining temperature, humidity, and production duration. These variables have different units and do not directly measure the same construct; therefore, they

must not be added in their raw form. Moreover, temperature and humidity alone cannot establish microbiological safety. For the present revision, the output is described more cautiously as a preliminary operational risk indicator, not a validated hygiene score. Its numerical use should remain disabled or explicitly marked exploratory until the process-specific reference limits, normalization method, weights, and thresholds have been documented and validated.

A normalized weighted-score model may be considered only after defining process-specific limits. For a future validated implementation, each parameter can be mapped to a dimensionless risk score r_i in the interval $[0, 1]$, where 0 represents a condition within the defined operating target and 1 represents the maximum risk level defined for that parameter. The composite score would then be $HI^* = \sum(w_i \times r_i)$, subject to $\sum w_i = 1$ and $w_i \geq 0$. This is a proposed model structure, not a calculated result from the current study.

$$HI = w_1T + w_2H + w_3D$$

Where:

HI = Hygiene Index

T = Temperature parameter

H = Humidity parameter

D = Production duration

w = weight coefficient of each parameter

Because validated thresholds are not available in the current evidence, the categories Low Risk, Moderate Risk, and High Risk should be treated as provisional interface labels only. They must not be interpreted as confirmed food-safety classifications until the thresholds have been justified against relevant requirements and the algorithm has been evaluated.

- Low Risk.
- Moderate Risk.
- High Risk.

The algorithm is used to provide automatic risk classification for production hygiene monitoring.

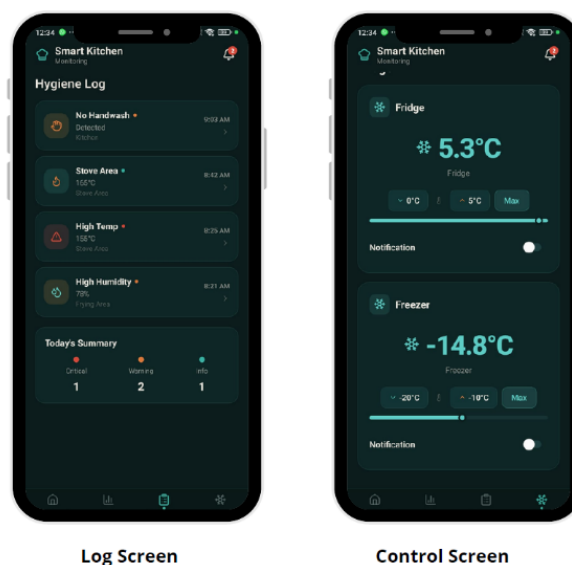


Figure 5. Flowchart of Hygiene Index Calculation Algorithm

2.6. QR Traceability System

The system integrates QR-based traceability to record production batch information. Each production batch is assigned a QR code that contains production parameters and monitoring results. The recorded production information includes:

- Production date and time.
- Temperature monitoring data.
- Humidity monitoring data.
- Production duration.
- Hygiene index status

The QR code enables easy access to production information by scanning the code through the mobile application.

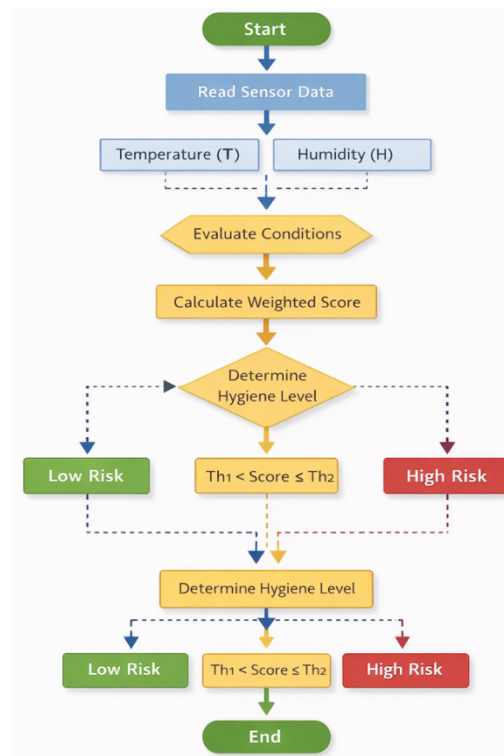


Figure 6. QR Code-Based Production Traceability System

2.7. System Testing

The available testing evidence is preliminary and consists of partial data and interface screenshots. The documentation supplied for this revision does not establish the number of test runs, duration, number of production batches, sensor calibration results, packet-loss rate, end-to-end latency, uptime, or QR scan success rate. Consequently, these metrics are not reported as completed tests. Before the manuscript can make quantitative performance claims, the prototype should be tested using a documented protocol: (1) compare sensor readings with a calibrated reference instrument over the intended operating range; (2) calculate mean absolute error (MAE) and, where appropriate, root mean square error (RMSE); (3) send a known number of data packets and record received packets and packet loss; (4) timestamp sensor acquisition and dashboard display to estimate latency; (5) repeat QR scans across a documented number of batch codes; and (6) report the test duration and number of batches. Only measurements actually collected should be inserted into the final results.

3. RESULTS AND DISCUSSION

This section describes the prototype features that can be inspected from the available partial data and interface screenshots. Since a complete quantitative evaluation has not been documented, the results are presented as preliminary functional observations rather than evidence of validated sensor accuracy, communication reliability, improved recording accuracy, or food-safety effectiveness.

3.1. System Implementation

The proposed Smart Kitchen monitoring system was implemented using IoT sensors integrated with a microcontroller-based edge computing device and a mobile monitoring application. The system continuously collects environmental data from the production area and transmits the data to the cloud database through wireless communication. The system interface is designed to provide real-time visualization of production parameters such as frying temperature, environmental humidity, hygiene index level, and production duration. Users can access the monitoring system through a mobile application that displays the data in a dashboard format. The main dashboard displays several key monitoring indicators including:

- a. Real-time temperature monitoring.
- b. Environmental humidity monitoring.
- c. Hygiene risk index indicator.
- d. Production timer.
- e. Sensor status monitoring

The dashboard interface allows operators to quickly identify abnormal production conditions and take corrective actions.



Figure 7. Smart Kitchen Monitoring Dashboard Interface

3.2. Real-Time Monitoring Performance

The monitoring system collects environmental data from sensors installed in the production environment. The collected data are transmitted to the cloud database and visualized in the mobile application in real time. The monitoring system measures several parameters including frying oil temperature, environmental humidity, and cold storage temperature. These parameters are important for maintaining product quality and ensuring food safety during the production process.

Table 3 presents an example of monitoring data obtained from the Smart Kitchen system during the production process.

Table 3. Example of Environmental Monitoring Data				
Time	Temperature (°C)	Humidity (%)	Hygiene Index	Status
08:00	150	70	Moderate	Normal
08:10	155	72	Moderate	Normal
08:20	160	75	High	Warning
08:30	152	71	Moderate	Normal
08:40	148	69	Low	Safe

Sumber : Data Primer

3.3. Historical Data Visualization

The Smart Kitchen monitoring system provides historical data visualization through graphical analysis features. These graphs allow users to observe trends in environmental conditions over time. The graph analytics module displays historical data for temperature and humidity monitoring, enabling operators to identify production patterns and potential environmental anomalies. The graphical visualization supports decision-making by allowing production managers to evaluate the stability of the production process.

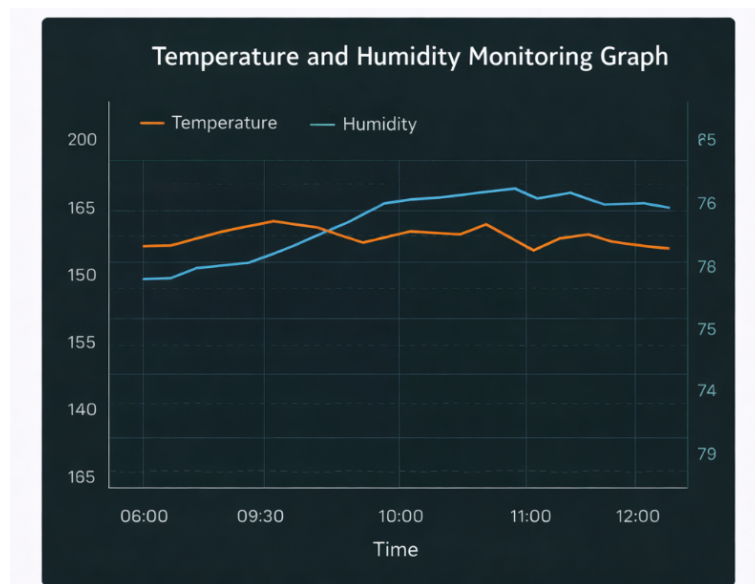


Figure 8. Temperature and Humidity Monitoring Graph

The historical data analysis helps identify fluctuations in production conditions and supports preventive actions to maintain product quality.

3.4. Hygiene Index Evaluation

The hygiene index is calculated automatically based on environmental parameters including temperature, humidity, and production duration. The algorithm processes sensor data and generates a hygiene risk classification that indicates the safety level of the production environment. The hygiene index classification consists of three categories:

- Low Risk. Production conditions are stable and within safe environmental limits.
- Moderate Risk. Environmental parameters approach threshold limits and require monitoring.
- High Risk. Environmental conditions exceed acceptable limits and may affect food safety.

The hygiene index monitoring allows operators to identify potential hygiene risks during the production process and take corrective actions when necessary.

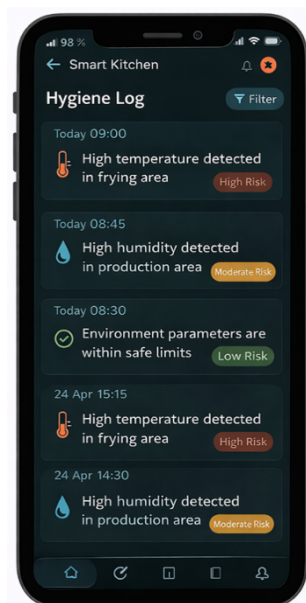


Figure 9. Hygiene Monitoring Log Interface

The hygiene log records events such as abnormal temperature conditions or humidity spikes that may affect production quality.

3.5. Cold Storage Monitoring

The Smart Kitchen monitoring system also includes a cold storage monitoring module that monitors refrigerator and freezer temperature in real time. Maintaining stable storage temperatures is essential for preserving raw materials and semi-processed food products. The monitoring system records temperature values and generates alerts when abnormal temperature conditions occur. This feature helps ensure that raw materials remain within safe storage conditions. Table 4 shows example monitoring results from the cold storage monitoring module.

Storage Type	Temperature (°C)	Standard Range	Status
Refrigerator	5.3	0 – 5	Warning
Freezer	-14.8	-20 – -10	Normal

Sumber : Data Primer

The values in Table 4 show the intended presentation of cold-storage readings. However, the refrigerator value of 5.3 °C is above the table's stated range of 0–5 °C and must not be labelled “Normal” under that same range. The status should be changed to “Warning” if 0–5 °C is the justified target for the food concerned, or the range must be revised only if a suitable authoritative requirement supports a different limit. The freezer range must likewise be justified for the specific food and storage purpose.

3.6. QR-Based Production Traceability

The Smart Kitchen monitoring system integrates a QR-based production traceability mechanism. Each production batch is assigned a unique QR code containing production information. The QR code stores information including:

- Production date.
- Environmental monitoring parameters.
- Production duration
- Hygiene index status

The interface indicates the intended workflow for linking a production batch to a QR identifier. The available materials do not include a documented QR test count or scan-success rate; therefore, the function should be described as implemented in the prototype only if confirmed, and its reliability should not be quantified until measured.



Figure 10. QR Code Production Traceability Interface

This feature provides an effective solution for documenting production history and improving consumer trust in food SME products.

3.7. System Evaluation

The prototype brings together the intended sensor-monitoring, cloud-storage, mobile-dashboard, and QR-linked batch-record functions. The current evidence is not sufficient to conclude that the system is accurate, reliable, or superior to manual monitoring. These claims require calibrated sensor comparisons, communication

and latency measurements, repeated functional tests, and a documented comparison with the existing recording workflow. The prototype should therefore be interpreted as an initial integrated design that requires further empirical validation.

4. CONCLUSION

This study presented an IoT-based monitoring prototype intended to support the observation of selected food-production conditions and QR-linked batch documentation in Indonesian MSMEs settings. The design integrates sensor inputs, a microcontroller, cloud-based records, and a mobile dashboard. Available partial data and interface screenshots demonstrate the intended monitoring workflow, but do not constitute a complete performance evaluation.

The current study does not yet provide sufficient evidence to quantify sensor accuracy, communication reliability, system latency, QR scan reliability, or improvement in recording accuracy. The operational risk indicator also requires a documented normalization procedure, justified weights, process-specific thresholds, and validation against appropriate reference criteria. Accordingly, the prototype should not be presented as a validated food-safety assessment system.

The contribution of this work is an initial integrated prototype design for environmental monitoring and digital batch identification. Future work should document field testing with a clearly identified MSMEs setting, testing duration, number of production batches, calibrated reference measurements, communication metrics, QR tests, and relevant food-safety requirements. Further development may include validated risk scoring and predictive analytics, but these remain future research directions rather than demonstrated capabilities of the present prototype.

ACKNOWLEDGEMENTS

The authors would like to express their sincere gratitude to Institut Teknologi Batam (ITEBA) for providing institutional support and research facilities during the development of this study. The authors also acknowledge the support of the Institute for Research and Community Service (LPPM) Institut Teknologi Batam for facilitating and supporting the research activities related to this work.

REFERENCES

- Aghenta, L. O., & Iqbal, M. T. (2019). Low-cost, open-source IoT-based SCADA system design using thinger.IO and ESP32 thing. *Electronics* (Switzerland), 8(8), 1–24. <https://doi.org/10.3390/electronics8080822>
- Aguiar, M. L., Gaspar, P. D., Silva, P. D., Domingues, L. C., & Silva, D. M. (2022). Real-Time Temperature and Humidity Measurements during the Short-Range Distribution of Perishable Food Products as a Tool for Supply-Chain Energy Improvements. *Processes*, 10(11). <https://doi.org/10.3390/pr10112286>
- Al-Amri, R., Murugesan, R. K., Man, M., Abdulateef, A. F., Al-Sharafi, M. A., & Alkahtani, A. A. (2021). A review of machine learning and deep learning techniques for anomaly detection in iot data. *Applied Sciences* (Switzerland), 11(12). <https://doi.org/10.3390/app11125320>
- Ausawanetmanee, P., Thavorn, J., Chandrachai, A., Klongthong, W., Vchirawongwin, V., & Ekgasit, S. (2024). Consumer acceptance of an innovative Bio-QR code traceability system for edible bird's nest. *Journal of Open Innovation: Technology, Market, and Complexity*, 10(1), 100169. <https://doi.org/10.1016/J.JOITMC.2023.100169>
- Bouzembrak, Y., Klüche, M., Gavai, A., & Marvin, H. J. P. (2019). Internet of Things in food safety: Literature review and a bibliometric analysis. *Trends in Food Science and Technology*, 94(April), 54–64. <https://doi.org/10.1016/j.tifs.2019.11.002>
- da Costa, T. P., Gillespie, J., Cama-Moncunill, X., Ward, S., Condell, J., Ramanathan, R., & Murphy, F. (2023). A Systematic Review of Real-Time Monitoring Technologies and Its Potential Application to Reduce Food Loss and Waste: Key Elements of Food Supply Chains and IoT Technologies. *Sustainability* (Switzerland), 15(1). <https://doi.org/10.3390/su15010614>
- De Silvestri, A., Ferrari, E., Gozzi, S., Marchi, F., & Foschino, R. (2018). Determination of temperature dependent growth parameters in psychrotrophic pathogen bacteria and tentative use of mean kinetic

temperature for the microbiological control of food. *Frontiers in Microbiology*, 9(DEC), 1–12. <https://doi.org/10.3389/fmicb.2018.03023>

- Domínguez-Bolaño, T., Campos, O., Barral, V., Escudero, C. J., & García-Naya, J. A. (2022). An overview of IoT architectures, technologies, and existing open-source projects. *Internet of Things*, 20, 100626. <https://doi.org/10.1016/J.IOT.2022.100626>
- Hamdan, S., Ayyash, M., & Almajali, S. (2020). Edge-computing architectures for internet of things applications: A survey. *Sensors (Switzerland)*, 20(22), 1–52. <https://doi.org/10.3390/s20226441>
- Li, P., Yang, J., Jiménez-Carvelo, A. M., & Erasmus, S. W. (2024). Applications of food packaging quick response codes in information transmission toward food supply chain integrity. *Trends in Food Science & Technology*, 146, 104384. <https://doi.org/10.1016/J.TIFS.2024.104384>
- McMeekin, T. A., Brown, J., Krist, K., Miles, D., Neumeyer, K., Nichols, D. S., Olley, J., Presser, K., Ratkowsky, D. A., Ross, T., Salter, M., & Soontranon, S. (1997). Quantitative Microbiology: A Basis for Food Safety. *Emerging Infectious Diseases*, 3(4), 541–549. <https://doi.org/10.3201/eid0304.970419>
- Popa, A., Hnatiuc, M., Paun, M., Geman, O., Hemanth, D. J., Dorcea, D., Son, L. H., & Ghita, S. (2019). An intelligent IoT-based food quality monitoring approach using low-cost sensors. *Symmetry*, 11(3). <https://doi.org/10.3390/sym11030374>
- Protopappas, L., Bechtsis, D., & Tsotsolas, N. (2025). IoT Services for Monitoring Food Supply Chains. *Applied Sciences (Switzerland)*, 15(13), 1–17. <https://doi.org/10.3390/app15137602>
- Ramirez, J., Manuel, L., & Fernandez, E. (2020). Monitoring of Temperature in Retail Refrigerated and Software. *Sensors*, 20(864), 2–18.
- Rassam, M. A., Zainal, A., & Maarof, M. A. (2013). Advancements of data anomaly detection research in Wireless Sensor Networks: A survey and open issues. *Sensors (Switzerland)*, 13(8), 10087–10122. <https://doi.org/10.3390/s130810087>
- Saini, J., Dutta, M., & Marques, G. (2020). Indoor air quality monitoring systems based on internet of things: A systematic review. *International Journal of Environmental Research and Public Health*, 17(14), 1–22. <https://doi.org/10.3390/ijerph17144942>
- Shi, X., An, X., Zhao, Q., Liu, H., Xia, L., Sun, X., & Guo, Y. (2019). State-of-the-art internet of things in protected agriculture. *Sensors (Switzerland)*, 19(8). <https://doi.org/10.3390/s19081833>
- Urbano, O., Perles, A., Pedraza, C., Rubio-Arreaz, S., Castelló, M. L., Ortola, M. D., & Mercado, R. (2020). Cost-effective implementation of a temperature traceability system based on smart rfid tags and iot services. *Sensors (Switzerland)*, 20(4). <https://doi.org/10.3390/s20041163>
- Visconti, P., de Fazio, R., Velázquez, R., Del-Valle-soto, C., & Giannoccaro, N. I. (2020). Development of sensors-based agri-food traceability system remotely managed by a software platform for optimized farm management. *Sensors (Switzerland)*, 20(13), 1–43. <https://doi.org/10.3390/s20133632>