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Designing a Chicken Egg Incubator with IoT-Based Control

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Abstract: This study developed an Internet of Things (IoT)-based egg incubator system capable of automatically controlling and monitoring temperature and humidity. The system was designed using an ESP32 microcontroller, a DHT22 sensor, an LCD display, and a mobile application built on the Blynk platform for remote monitoring and control. The development process included the design of the electronic system, construction of the physical housing, and a 21-day functionality test using ten local chicken eggs. Test results showed that the system was able to maintain temperatures between 37.1°C and 37.7°C and humidity levels between 41% and 73%, which are consistent with the physiological requirements of chicken embryos. Three chicks successfully hatched on day 21. A survey of eleven poultry farmers revealed that 72.7% expressed interest in using the system, and 100% indicated the need for user training. These findings demonstrate that the developed IoT incubator system not only meets the technical requirements for egg incubation but also shows strong potential for adoption by target users. This study contributes to the development of a low-cost, portable, and user-friendly incubation system for small and medium-scale poultry farming.

Keywords: Internet of Things, egg incubator, temperature, humidity, automation, smart farming

1. Introduction

The hatching process of chicken eggs is a crucial component in the poultry farming industry (Ogbu & Oguike, 2018). Traditionally, this process is carried out either naturally using a brooding hen or through manual incubators that require intensive monitoring of temperature and humidity. However, in modern agricultural settings that demand efficiency and scalability, automation technology has become a necessity. As such, the integration of Internet of Things (IoT) technology into egg incubators represents a significant innovation that enhances operational efficiency and increases hatching success rates.

The hatching process of chicken eggs is a crucial component in the poultry farming industry, directly influencing productivity and sustainability (Ogbu & Oguike, 2018). Traditionally, hatching is conducted either naturally using brooding hens or through manual incubators, both of which require close and continuous monitoring of temperature, humidity, and egg rotation to ensure optimal embryonic development. However, these traditional methods present limitations in terms of labor intensity, inconsistency in environmental control, and scalability. In response to these challenges, the integration of automation and Internet of Things (IoT) technologies in modern incubator systems has emerged as a transformative approach. IoT-enabled incubators are equipped with sensors and microcontrollers that monitor and regulate critical environmental parameters in real time, significantly improving hatching efficiency and reducing human error.

This technological shift is evident globally. In Brunei and Canada, the implementation of smart agriculture tools—including IoT-integrated incubators—has enhanced hatchability rates and reduced energy consumption, contributing to more sustainable and large-scale poultry production (Hambali et al., 2020; Astill et al., 2020). Precision agriculture approaches have optimized environmental conditions and animal welfare, reinforcing the importance of digital monitoring systems in poultry farming (Maharjan & Liang, 2020). Meanwhile, locally adapted solar-powered IoT incubators offer cost-effective and scalable solutions, empowering smallholder farmers while reducing reliance on imported technologies (Cheepati & Balal, 2024). Overall, the integration of IoT technologies in egg incubation not only

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represents a milestone in agricultural digitalization but also supports global objectives of food security, technological inclusion, and sustainable rural development.

This project developed an egg incubator system equipped with IoT technology for automatic control of temperature and humidity. The technology enables real-time monitoring and remote control via a mobile application. A study by Abidin et al. (2018) demonstrated that implementing IoT-based control systems in incubators can stabilize incubation parameters and reduce the need for human intervention. Furthermore, according to Rakhmawati et al. (2023), the incorporation of intelligent controllers such as fuzzy logic within IoT systems allows for more precise regulation of temperature and humidity, thereby improving embryo survival rates.

The main challenges faced by small-scale poultry farmers include sudden weather changes, the high cost of commercial incubators, and difficulties in consistently maintaining optimal temperatures. According to Lestari et al. (2020), the ideal incubation temperature for chicken eggs ranges between 37°C and 38°C, with humidity levels between 50% and 65% However, Malaysia's tropical climate variability makes it difficult to maintain these parameters consistently. Furthermore, the cost of existing IoT-enabled incubator machines can reach RM500–RM2000 per unit, rendering them economically inaccessible to small-scale farmers. Temperature instability also significantly affects embryo health. Khan et al. (2021) detailed how temperature fluctuations can impair embryo development and increase chick mortality rates.

In response, this study bridges the gap between the need for high-tech automation and the demand for low-cost production. It proposes a cost-effective approach to developing a smart incubator that is not only affordable but also adds value to local farming productivity. The study draws inspiration from models proposed by Peprah et al. (2022) and Uzodinma et al. (2020), which emphasize the integration of solar power and GSM/IoT-based control as sustainable and scalable solutions.

As a solution, this research establishes three primary objectives: (1) to design a precise control and monitoring system for temperature and humidity using IoT technology; (2) to develop a prototype of an IoT-based egg incubator capable of maintaining a stable temperature of approximately 37.90°C; and (3) to test the effectiveness of the integrated control system on hatch success rates in real-life conditions. The implementation of this project is expected to drive the broader adoption of smart technologies within small-scale agricultural practices in Malaysia.

2. Methodology

This study employed a product development research design aimed at designing and developing an Internet of Things (IoT)-based egg incubator system. The approach consisted of three main phases: system design, product development and testing, and product effectiveness evaluation through user feedback.

In the design phase, the researchers developed the electronic circuitry and control software using an ESP32 microcontroller and a DHT22 temperature and humidity sensor. Temperature and humidity data were displayed via an I2C LCD module, while the heating system was controlled through an automatic relay that managed both the heating bulb and ventilation fan. The system was also integrated with a mobile application using the Blynk platform for real-time monitoring.

The physical housing of the incubator was constructed using materials such as plywood and acrylic, based on 3D models and orthographic drawings. Each component of the device was designed in a modular format to facilitate easy maintenance and customization by users.

2.1 Product Test

After the prototype incubator was completed, a functionality test was conducted in a real-world environment to evaluate the feasibility of automatic temperature and humidity control as well as monitoring through a mobile interface. The test was carried out over 21 days—the average incubation period for chicken eggs—using 10 local (kampung) chicken eggs.

Throughout the incubation period, temperature and humidity data were continuously recorded using the real-time monitoring feature of the IoT system. The target temperature range was maintained between 37.5°C and 38.0°C, while the humidity level was kept within 50–65%. The hatching success rate at the end of the test was used as one of the key performance indicators for the system.

2.2 User Feedback (Survey)

The final phase involved evaluating the system's performance and usability from the users' perspective. A survey was conducted using structured questionnaires distributed to five (5) target users, consisting of small-scale farmers, engineering students, and micro-entrepreneurs who are potential users of the system.

The questionnaire covered four main aspects: (1) understanding of the system's functions, (2) ease of use, (3) efficiency of remote monitoring and control, and (4) potential applicability in real-world poultry farming. Respondents rated these aspects using a five-point Likert scale (1 = strongly disagree to 5 = strongly agree).

The feedback was analyzed descriptively to determine the level of user acceptance and identify areas for improvement in future development. These findings not only serve as a foundation for refining the system's design but also contribute to a deeper understanding of the needs and priorities of users in the small-scale poultry farming sector.

2.3 System Design and Development

This project underwent a comprehensive design and development phase for an IoT-based egg incubator system, beginning with electronic schematic sketches and 3D physical designs, and culminating in a fully functional final product. The system design incorporated key components such as an ESP32 microcontroller, a DHT22 sensor for temperature and humidity monitoring, relays for controlling the heating element and fan, and an LCD interface for real-time display. The system was also integrated with a mobile application via the Blynk platform, enabling users to monitor and control the incubator remotely.

The physical design of the prototype featured an incubator with approximate dimensions of 46 cm in height and 41 cm in width, providing sufficient incubation space for small-scale hatching. Temperature and humidity readings were displayed on the LCD screen, while a transparent window on the door allowed users to observe the internal conditions without opening the chamber—thus maintaining stable internal temperatures. The development process demonstrated that the technical design could be effectively implemented using locally available materials and low-cost electronic components.

3. Findings

3.1 Technical Analysis of the Incubator System

Initial testing of the heating system in Figure 1 showed that the internal temperature of the incubator could reach 37.9°C within 15 minutes. The temperature started at 33.7°C and gradually increased to 37.5°C within five minutes, then to 37.8°C after ten minutes, and finally stabilized at 37.9°C after fifteen minutes. This temperature stability demonstrates the effectiveness of the automatic temperature control system developed. It indicates that the system is capable of regulating the internal environment responsively and efficiently, meeting the technical requirements for chicken egg incubation.

Actual testing over a 21-day incubation cycle revealed that the temperature was successfully maintained between 37.1°C and 37.7°C, while the humidity ranged between 41% and 73%. The data showed a progressive increase in humidity, consistent with the physiological needs of chicken embryo development, which requires higher humidity levels approaching days 18 to 21 (the lockdown phase). Hatching began on day 19, and by day 21, three eggs successfully hatched under continuous automatic monitoring. These findings confirm that the system functions effectively in providing an optimal environment for embryo development and successful hatching.

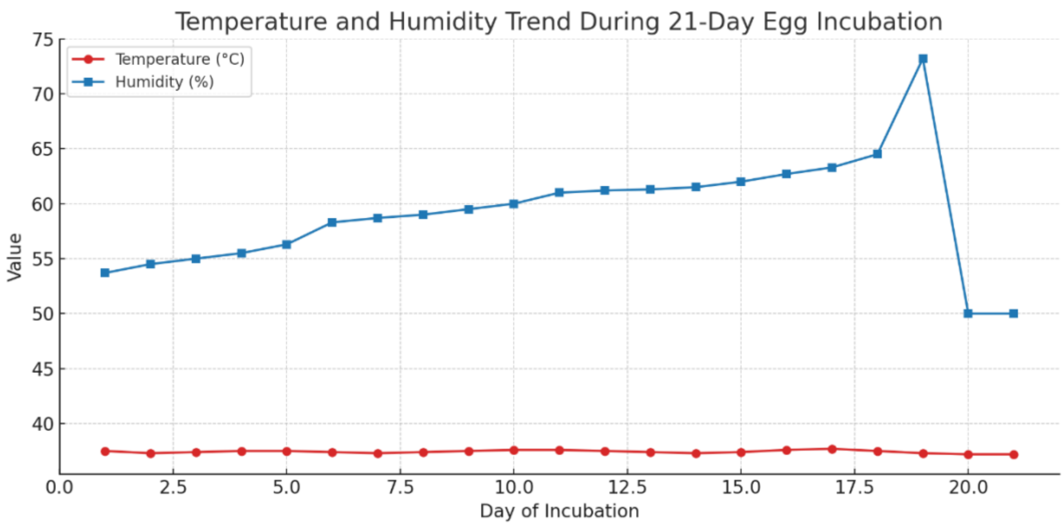

Figure 1. Temperature and Humidity Trends Over the 21-Day Incubation Period

3.2 User Feedback

A survey conducted among 11 poultry farmers represented in Figure 2 revealed positive feedback regarding the usability of the system. A total of 72.7% of respondents expressed interest in using the IoT-based incubator, despite 72.7% of them having no prior experience with incubator systems. This indicates a significant market potential for the system among new users seeking more accessible and efficient hatching solutions.

Interestingly, all respondents (100%) agreed that they would require training or guidance to operate the IoT-based incubator, highlighting the importance of user support in the successful implementation of this technology. Additionally, 90.9% of respondents indicated that they preferred the system to be accessible by more than one user. This suggests the potential for developing a multi-user interface to allow shared access among farmers or household members, thereby enhancing the system's flexibility and user collaboration

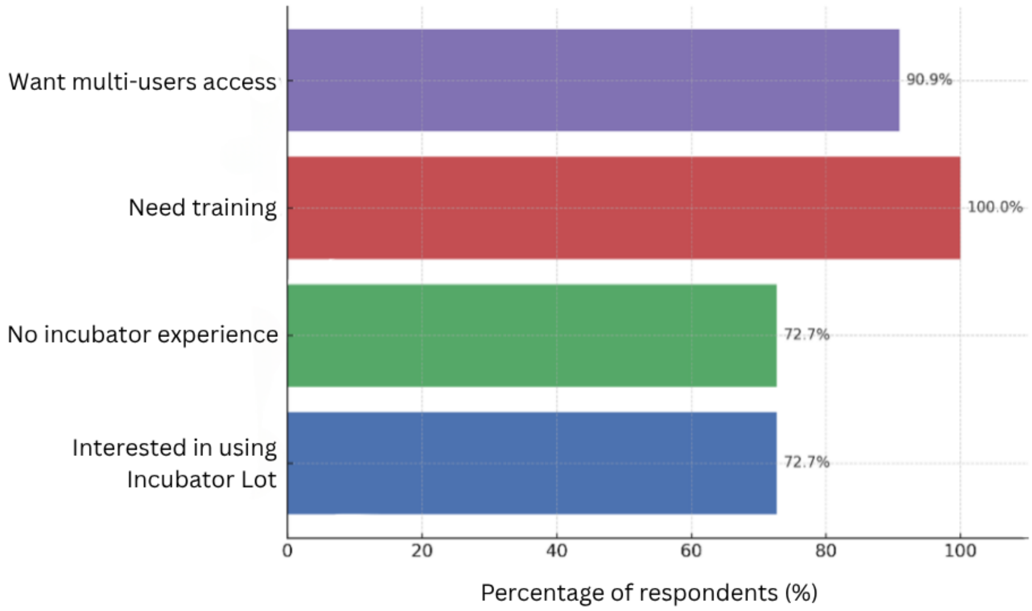

Figure 2. Feedback from Poultry Farmers on the Usability of IoT-Based Incubator System

4. Discussion

The technical performance of the Internet of Things (IoT)-based incubator prototype demonstrates a significant achievement in meeting the core objective of this study: to design a precise and stable environmental control system for egg incubation. The system's ability to reach and stabilize at the target temperature of 37.9°C within just 15 minutes showcases the efficiency of the heating and control logic. More importantly, maintaining the temperature between 37.1°C and 37.7°C and humidity between 41% and 73% throughout the 21-day incubation period aligns with the established optimal ranges for chicken embryo development. The gradual increase in humidity observed in the later stages of incubation mirrors the natural physiological requirements for the lockdown phase, which is critical for successful hatching. The successful hatching of three chicks validates that the system can sustain a viable environment from the beginning to the end of the incubation cycle, directly addressing the challenge of temperature instability that often leads to increased chick mortality.

These findings are consistent with and build upon a growing body of research advocating for IoT integration in agriculture. The successful implementation of an ESP32 microcontroller and the Blynk platform for remote monitoring confirms that effective smart farming tools can be developed using low-cost, accessible components. This study reinforces the conclusions of Abidin et al. (2018) who showed that IoT control systems reduce the need for constant human intervention while stabilizing incubation parameters. Furthermore, the stable environment achieved in this prototype provides a foundational baseline that could be further enhanced with more advanced controllers, such as the fuzzy logic systems described by Rakhmawati et al. (2023) to potentially improve embryo survival rates even further. By creating a functional, low-cost model, this research contributes a practical solution that aligns with global trends in precision agriculture, which have been shown to enhance hatchability and sustainability in diverse contexts.

Beyond technical efficacy, the user feedback analysis reveals a strong potential for market adoption, particularly among farmers new to incubation technology. The fact that 72.7% of respondents are interested in using the system, despite a similar percentage having no prior experience, indicates that the incubator addresses a significant need for accessible and automated hatching solutions. This highlights a key market gap that a user-friendly, low-cost system can fill. However, the unanimous agreement (100%) among respondents on the necessity of training is a critical insight. It underscores that technological readiness must be matched with robust user support and documentation to ensure successful adoption and implementation. Technology developers must therefore prioritize creating comprehensive training modules alongside the physical product to bridge the knowledge gap for novice users.

Finally, certain limitations and practical challenges must be considered for future development. While the system successfully facilitated the hatching of three chicks, the overall hatch rate warrants a nuanced discussion. Factors beyond temperature and humidity, such as initial egg fertility and handling, could have influenced the outcome and should be controlled for in future studies to isolate the system's direct impact more precisely. Moreover, the suggestion from 90.9% of users for multi-user access points to a need for more flexible and collaborative software design, catering to the shared nature of small-scale agricultural work. The successful deployment of this technology at a larger scale will also depend on addressing external factors like inconsistent internet access and power supply, which remain significant hurdles in many rural areas. Incorporating alternative power sources, as suggested by studies like Peprah et al. (2022) and Cheepati & Balal (2024), could be a crucial next step in creating a truly resilient and scalable solution for small and medium-scale poultry farming in Malaysia and beyond..

5. Conclusion

This project successfully developed a prototype of an IoT-based chicken egg incubator that functions effectively in maintaining stable temperature and humidity levels throughout the incubation cycle. The system not only meets the technical requirements for embryonic development but also demonstrates strong potential for user acceptance, particularly among small-scale poultry farmers. Its ability to operate automatically, coupled with remote monitoring integration via a mobile application, allows for more efficient and flexible incubation management.

In addition, positive user feedback highlights the importance of training and a user-friendly interface as key factors in ensuring the system's practical effectiveness.

Overall, the development of this IoT-based incubator provides a low-cost solution that can help improve poultry productivity in rural areas. Further research is recommended to enhance aspects such as alternative power supply systems, multi-user support, and advanced automation incorporating artificial intelligence and machine learning.

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Conflict of Interest

The authors declare no conflicts of interest.

References

Abidin, A. A., Rashid, A. T., & Mokayef, M. (2018). Design and Implementation of Intelligent Control System for Egg Incubator Based on IoT Technology. Proceedings of ICEESE 2018.

Astill, J., Dara, R. A., Fraser, E. D., Roberts, B., & Sharif, S. (2020). Smart poultry management: Smart sensors, big data, and the internet of things. Computers and Electronics in Agriculture, 170, 105291. https://doi.org/10.1016/j.compag.2020.105291

Celebioglu, C., & Topalli, A. K. (2024). *IoT-based incubator monitoring and machine learning powered alarm predictions. The Journal of Health Care Information Management* (SAGE). journals.sagepub.com

Cheepati, K. R., & Balal, N. (2024). Solar Powered Thermoelectric Air Conditioning for Temperature Control in Poultry Incubators. Sustainability, 16(11), 4832. https://doi.org/10.3390/su16114832

Ferdiansyah, M., Mariya, L., & Kholifah, S. K. (2025). *Optimization of Energy Efficiency and Hatchability Rates in IoT-Based Egg Incubators. International Journal Software Engineering and Computer Science*, 5(1), 357–367. journal.lembagakita.org

Hambali, M. F. H., Patchmuthu, R. K., & Wan, A. T. (2020, June). IoT based smart poultry farm in Brunei. In 2020 8th International Conference on Information and Communication Technology (ICoICT) (pp. 1-5). IEEE. https://doi.org/10.1109/ICoICT49345.2020.9166331

Khan, S., McWhorter, A. R., Moyle, T. S., & Chousalkar, K. K. (2021). Refrigeration of eggs influences the virulence of Salmonella Typhimurium. Scientific Reports, 11, 97135.

Lestari, I. N., Mulyana, E., & Mardi, R. (2020, September). The implementation of mamdani's fuzzy model for controlling the temperature of chicken egg incubator. In 2020 6th International Conference on Wireless and Telematics (ICWT) (pp. 1-5). IEEE.

Maharjan, P., & Liang, Y. (2020). Precision livestock farming: the opportunities in poultry sector. J. Agric. Sci. Technol. A, 10(2), 45-53. https://doi.org/10.17265/2161-6256/2020.02.001

Ogbu, O. C., & Oguike, M. A. (2018). Hatchability of fertile eggs in poultry industry. Journal of Agriculture and Sustainability, 12(1), 107-123.

Panumonwatee, G., Preecha, N., & Choosumrong, S. (2022). *Temperature and Humidity Monitoring System on Hatching Native Chickens Egg in Electric Incubator using Internet of Things Technology. Journal of Applied Research on Science and Technology*, 21(2), 79–88.

Peprah, F. et al. (2022). Design and construction of smart solar powered egg incubator based on GSM/IoT. Scientific African, 17, e01326. https://doi.org/10.1016/j.sciaf.2022.e01326

Rakhmawati, R., Irianto, F. D., Murdianto, A. L., & Rahman, A. Y. (2023). *Egg Incubator Temperature and Humidity Control Using Fuzzy Logic Controller. Jurnal RESTI*, 7(2), 318–325.

Uzodinma, E. O. et al. (2020). Performance study of a solar poultry egg incubator with phase change heat storage subsystem. Case Studies in Thermal Engineering, 18, 100593. https://doi.org/10.1016/j.csite.2020.100593