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RESEARCH PAPER

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MODERN ECO SMART EGG HATCHER

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Abstract: This study assesses the performance and viability of the Modern Eco-Smart Egg Hatcher, an automated, solar-powered system designed to optimize the poultry incubation process. To evaluate the system, the researchers used a Key Performance Indicator (KPI) approach to collect data from a purposively selected group of 20 respondents: 10 IT experts, 5 game fowl breeders, and 5 poultry farmers. The system was rigorously evaluated based on four primary criteria: accuracy, effectiveness, functionality, and reliability. Quantitative findings demonstrated exceptional performance and high satisfaction across all metrics, with the system achieving outstanding grand mean scores in functionality (4.94), reliability (4.86), effectiveness (4.84), and accuracy (4.78). A comparative analysis across the evaluator groups further underscored the system's success, with IT experts and end users reporting weighted means of 4.86 and 4.88, respectively. The study concludes that the hatcher is highly reliable, maintains ideal incubation conditions with minimal user intervention, and successfully meets the practical demands of its target beneficiaries.

Keywords: Eco-Smart Egg Hatcher, Poultry Incubation, Automated Agriculture, Key Performance Indicators (KPI), Solar-Powered System, System Evaluation, Smart Farming

1. INTRODUCTION

In recent years, advancements in agricultural technology have revolutionized traditional farming practices, bringing forth innovative solutions to enhance productivity while promoting sustainability. One such innovation is the Modern Eco Smart Egg Hatcher, which plays a crucial role in modern poultry farming.

In the world of poultry farming, the traditional methods of egg incubation have long been the foundation of hatching practices. However, these methods often come with challenges that can hinder productivity and efficiency, such as improper egg-handling procedures, inconsistent monitoring, and biological and environmental threats. Traditional egg incubation has several drawbacks. Turning the eggs during incubation is one way to ensure optimal hatchability and healthy embryonic growth. An additional difficulty arises when an egg experiences infertility or premature death, which could have an impact on nearby eggs. These difficulties underscore the importance of properly handling and managing eggs during incubation to maximize hatchability and ensure the quality of hatching eggs. Modern incubators are equipped with digital thermostats for precise temperature control, automatic egg turners to ensure even development, and humidity control systems, all of which are crucial for egg health. These technological enhancements not only improve hatching efficiency but also reduce the labor and attention required during incubation. It can hatch eggs artificially. It is a device that simulates avian incubation by maintaining a specific temperature range and humidity, with a turning mechanism to hatch the eggs. It allows the fetus inside the egg to grow without the mother needing to be present to provide warmth. The incubator also allows the eggs to incubate while eliminating external threats that could harm them (Wikipedia).

Artificial incubation is more advantageous for optimizing egg production because once a hen has finished laying, it does not take long to lay again. For natural hatching, the hen generally spends 21 days from incubation to hatching. It takes another period, from weeks to months, to raise chicks, and only then can it resume laying eggs. Therefore, building and utilizing the Modern Eco Smart Egg Hatcher helps improve chicken farming results.

The system, titled "Modern Eco Smart Egg Hatcher," is an innovative solution designed to support backyard chicken raisers and poultry farmers. It improves hatching rates through advanced microcontrollers and a well-programmed system. The device enables remote monitoring and control using a GSM module, allowing users to send and receive updates via SMS. Additionally, it promotes environmental sustainability by using solar power (photovoltaics) as its primary energy source. Overall, the system offers convenient and efficient operation, always ensuring the incubator functions properly.

OBJECTIVES OF THE STUDY

The general objective of this capstone project is to design and develop an advanced incubation system that enhances the overall egg hatching process by integrating modern technologies and innovative solutions. This system aims to address common challenges in traditional incubation methods, such as inconsistent power supply, lack of monitoring, and heavy reliance on manual intervention, thereby improving efficiency, reliability, and user convenience.

Specifically, the project seeks to incorporate solar power as a primary energy source to ensure a sustainable, eco-friendly, and reliable power supply, especially in areas with limited or unstable. In addition, the system is designed to provide real-time alerts via SMS (Short Message Service), allowing users to receive immediate updates on temperature changes, humidity levels, system status, and potential issues that may affect the incubation process.

Furthermore, the project focuses on designing an intuitive and user-friendly physical interface that enables users to easily operate and monitor the system, even with minimal technical knowledge. It also aims to develop a flexible and automated system that significantly reduces the need for constant human intervention while maintaining optimal incubation conditions. Lastly, the system is intended to provide simple, efficient, and reliable access for users with varying levels of technical skill, ensuring that both beginners and experienced users can use the technology effectively.

2. MATERIALS AND METHODS

This chapter presents the research design, participants, instrumentation process, data-gathering procedures, and data-analysis tools used in data treatment. In this context, the reasons that underpin the choice of area are explained. This includes explanations of the environment, sample, and sampling procedures, as well as data collection techniques and methods utilized in the research design and methodology. There are also explanations of the data collection and analysis procedures, as well as the instrument validation processes.

2.1 Design Method

The agile development method was the best-suited development process for the Modern Eco Smart Egg Hatcher. The said method was the best suited for the system. It requires the researcher or developer first to gather what the client really wants. After gathering the required data, it will then be carefully designed and taken into planning. That is why agile is best suited for the project, from gathering requirements to design and testing. It only ensures that the system is running and in good condition after handing it over to the client or user.

Figure 1: **Agile Model**

2.2 Requirements

The researcher first gathers data for the project. Several key considerations must be addressed to ensure project success. The process starts by defining key user stories and the problems they face during incubation. For example, farmers may require an incubator to operate without power shortages, which is the most important factor in the incubation process. Additionally, users need to provide updates via SMS, which is crucial for monitoring the eggs. This feature thus enables remote monitoring. Functional requirements also matter; the system's ability to regulate internal temperature is important in maintaining optimal conditions for egg hatching, aligned with the project's core objectives. Non-functional requirements, such as performance metrics and usability standards. For instance, temperature accuracy within a defined range and timed delivery of SMS notifications or updates. Technical considerations also matter; they will drive the incubator's functionality in hardware and software.

2.3 Design

Once the researcher has understood the requirements of the system to be developed. The design phase has begun. It includes an extensive design of the system's prototype. The researchers began designing the system according to the beneficiary's preferences.

2.4 Development

In this phase, the researchers began writing code and programming the system into its logical manner. In building the system, the researchers structured the code to integrate required features, such as sensors and an automatic egg turner. The researchers carefully programmed the system to ensure precise temperature regulation, humidity control, and SMS notifications.

2.5 Testing

After the system has been developed, it undergoes testing. The researchers test the system's functionality and reliability. After the system had been thoroughly examined for any fluctuations, some vulnerabilities were uncovered. The automatic egg turner does not function as intended. However, the researchers fixed the issue and completed the system on time.

2.6 Deployment

After successful testing, the researchers then deploy the system to its beneficiary. The researchers provide users with training to help them operate the system and explain its features. Researchers also remain available to provide ongoing support and maintenance to address any post-deployment issues that may arise, ensuring that the incubator continues to meet user requirements.

2.7 Review

In this phase, the researchers gather user feedback. It includes the system's performance, usability, and feature effectiveness, such as temperature and humidity, accuracy, and SMS notifications. This approach helps to improve further and enhance user satisfaction.

Flow of Study

The study's flow will be based on the Input-Process-

Output (IPO) Model, as illustrated in Figure 2. The three essential parts of the input for this study are as follows:

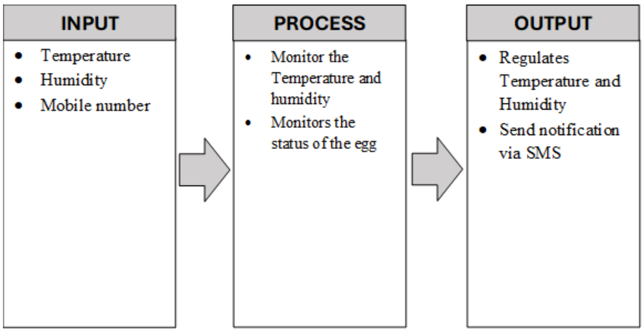

Figure 2: **Input-Process-Output Model**

Functional & Non-Functional Requirements

Software Requirements

Table 1 presents the software requirements for the system's development. It specified the minimum version of the software used in the development.

Table 1: **Software Requirements (Minimum)**

SOFTWARE	VERSION
Arduino IDE	Arduino 1.8.18

Hardware Requirements

Table 2 presents the hardware requirements for developing and utilizing the system.

Table 2: **Hardware Requirements (Recommended)**

DEVICE	SPECIFICATIONS
Microcontroller	NodeMCU ESP-32 38 pins
Temperature Sensor	DHT 11 Module
Humidity Sensor	DHT 11 Module
Display	LCD I2C 20x4
GSM Module	Sim900A GSM Module
Relay	2 Channel 5v low-trigger 2 Relay
AC Motor	220vac
Fan	220vac

System Flowchart

A system flowchart is a graphical representation of the flow of information or data through a system. It is commonly used in software development and other engineering fields to depict a system's components and processes visually.

This flowchart represents a basic system that takes input data, processes it, and produces an output result. Here is a breakdown of each component:

START: This symbol represents the start of the system flowchart.

INPUT data: This symbol represents the data fed into the system.

PROCESS data: This symbol represents the processing of the input data, which may involve various steps or algorithms.

OUTPUT result: This symbol represents the system's output, which may be a report, a graph, or another format.

END: This symbol represents the end of the system flowchart

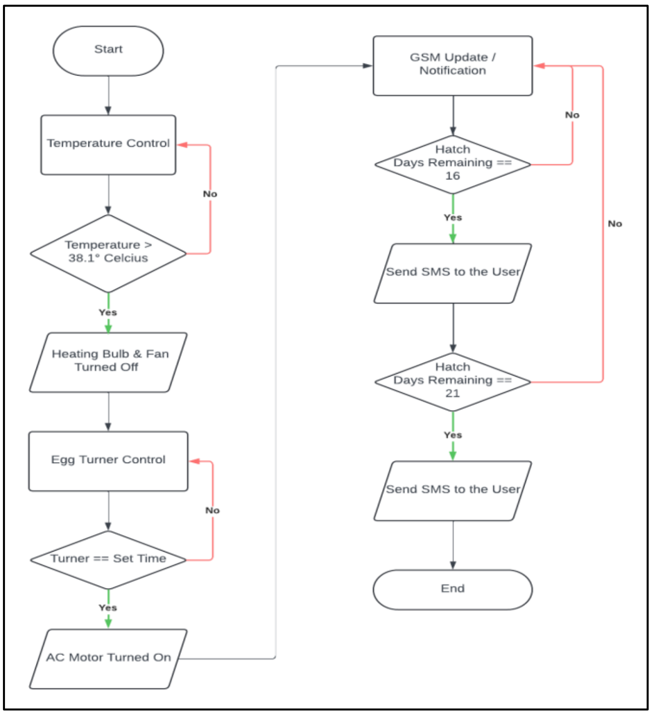

Figure 3 **System Flowchart**

System Architecture

System architecture refers to the design and structure of a computer system or software application. It includes the components of the system, their relationships, and how they work together to achieve the desired functionality.

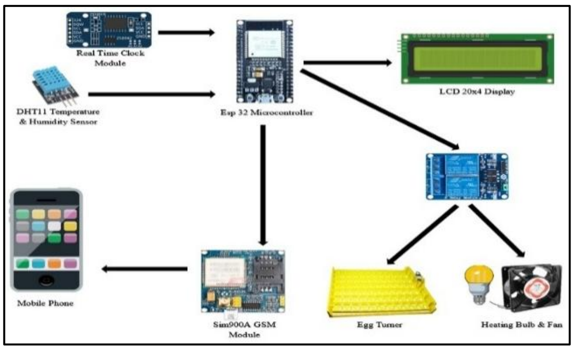

Figure 4: **System Architecture**

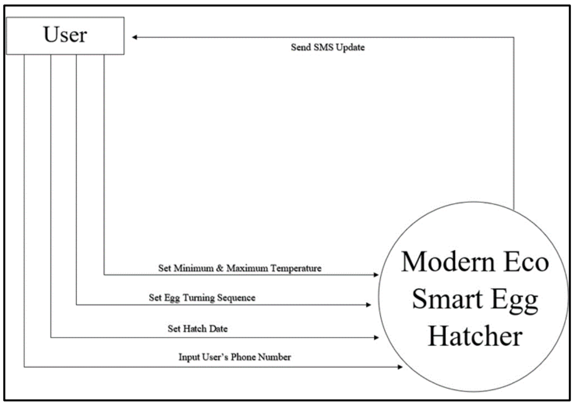

Figure 5: **Context Diagram**

Use Case Diagram

This section provides an overview both the hardware and software components used by the researchers in the project. Providing a brief specification of the components for your information.

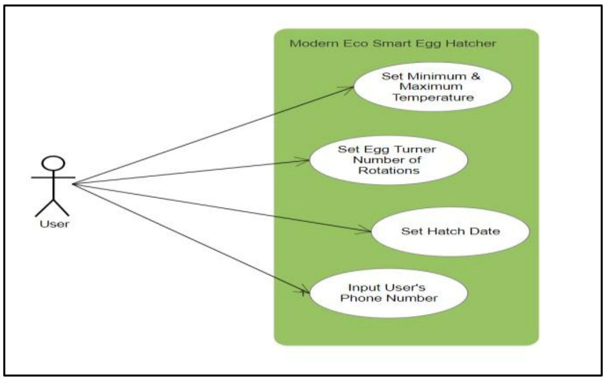

Figure 6 **Use Case Diagram**

Data Flow Diagram

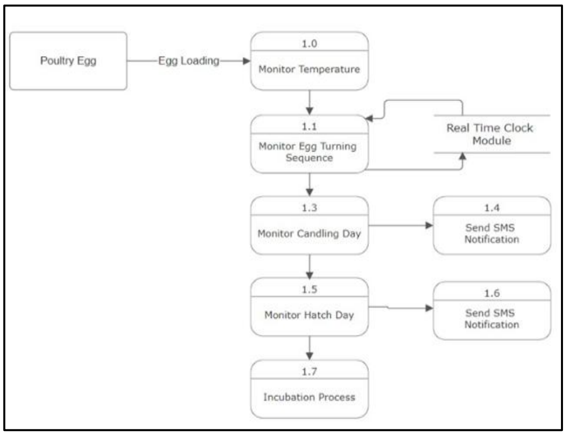

Figure 7 **Data Flow Diagram**

Figure 7 presents the Data Flow Diagram. This shows data flows in each device using a graphical representation. It visualizes the entire data process.

Circuit Diagram

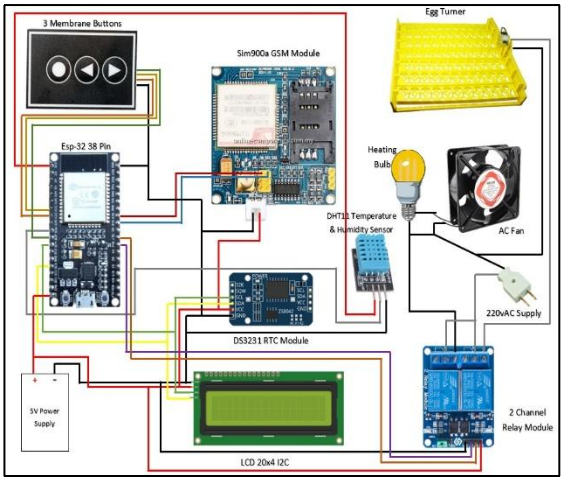

Figure 8 **Circuit Diagram**

Figure 8 presents the Internal Circuit component connections of the Modern Eco Smart Egg Hatcher. Providing a visual representation of the entire circuit.

User Interface and its Device

The figure below shows the system I/O devices. The user can view the settings on the LCD Display and set the desired system settings using its buttons.

Respondents

The respondents are Poultry Farmers, Gamefowl Breeders, or Hobbyists. Poultry farmers are the primary beneficiaries of this system; it will significantly improve their production, thus ensuring a reliable flow of livestock. For instance, it will help breed chickens used for egg production or hatch chicks, such as broilers, most likely for human consumption. On the other hand, Gamefowl Breeders is also a potential user of this system. Many game farms are having difficulty breeding their fowl naturally; therefore, using an artificial hatching method is another way to ensure successful breeding. Another potential user or beneficiary is people who use chickens for recreation or as a pastime.

Table 3: **Respondent**

RESPONDENTS	FREQUENCY	PERCENTAGE
IT Expert	10	50
Gamefowl Breeders	5	25
Poultry Farmers	5	25
Total	20	100

Environment

The researcher conducted the study at the beneficiary's location. The poultry is in Brgy. Po-ok, Municipality of Hinoba-an, Negros Occidental. The system was focused only on the beneficiary's residence.

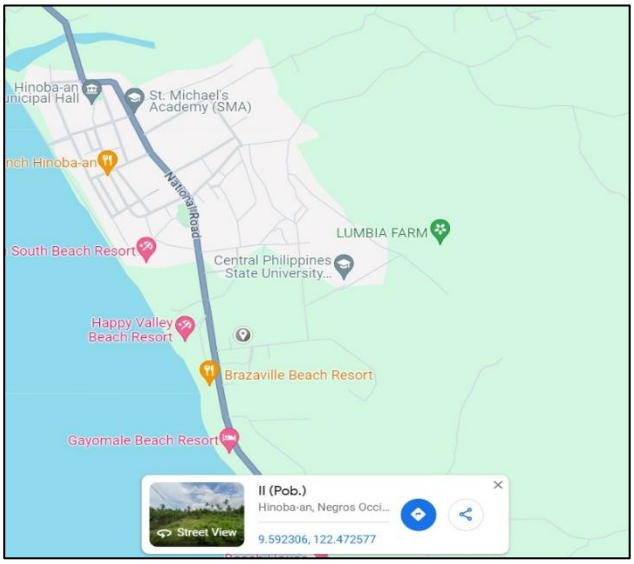

Figure 9: **Environment of the Study**

Instruments

The survey questionnaire was conducted to the poultry farmers, game fowl breeders, and hobbyists as the main data gathering instrument for the study.

The instrument was divided into two parts. The first part is their personal information. And the second part is where the questions are included, all about what problems they encountered and the difficulties in traditional breeding.

Table 4: **Likert Scale**

		Range Scale
4.21	5.00	Strongly Disagree
3.41	4.20	Disagree
2.61	3.20	Neither Agree nor Disagree
1.81	2.60	Agree
1	1.80	Strongly Disagree

Data Gathering Procedures

An interview was conducted to Mr. Levy Mahinay, caretaker of blue mamba game farm, to gather insights of Modern Eco Smart Egg Hatcher. The interview focused on the aspects related to gamefowl breeding. The first objective is to know about the experience of raising and breeding gamefowl of Mr. Mahinay. Inquiring the current practice which includes the use of manual traditional process of hatching gamefowl chicks. Exploring Mr. Mahinay's interest in modernization and the use of technology for easy and accurate results. Moreover, asking specific question's regarding real-time updates. Additionally specific requests, suggestions, and recommendations are greatly appreciated.

3. Results and Discussion

The research study involved 10 IT experts, 5 game fowl breeders, and 5 poultry farmers. These respondents evaluated the system based on its accuracy, effectiveness, functionality and reliability using the criteria developed by the researchers based on the questionnaire using the Key Performance Indicator approach.

Table 4 presents the average rating provided by the respondents for the accuracy of the system. The results reveal a high overall mean rating of 4.8, suggesting that the system's accuracy effectively meets the benefits and requirements

Table 5:**Accuracy**

ACCURACY	**Mean**	**Description**
The system can track eggs by their current status during the incubation cycle.	4.6	Agree
It effectively maintains ideal heat and moisture conditions for successful hatching.	4.85	Strongly Agree
3.The system ensures uniform heat distribution across all eggs.	4.85	Strongly Agree
4.The system differentiate between fertile and non-fertile eggs with high accuracy.	4.8	Agree
5. The system ensure that sensors provide accurate, real-time data that reflects the true incubation conditions.	4.9	Agree
Grand Mean	4.8	Agree

Table 5 presents the average rating provided by the respondents for the effectiveness of the system. The results reveal a high overall mean rating of 4.83, suggesting that the system effectively addresses the needs and requirements of the beneficiary in terms of its effectiveness. The high rating implies that the respondents perceive the system as highly effective.

Table 6: **Effectiveness**

EFFECTIVENESS	**Mean**	**Description**
System improves hatch rates compared to traditional incubators.	4.6	Agree
The system ensures consistent performance over multiple incubation cycles.	4.85	Strongly Agree
The system ensures successful hatching with minimal user intervention.	4.95	Strongly Agree
The system effectively customizes incubation conditions based on user preferences or specific egg requirements.	4.95	Strongly Agree
The system handle varying egg loads while maintaining high effectivseness.	4.8	Agree
Grand mean	4.83	Strongly Agree

Table 7: **Functionality**

FUNCTIONALITY	Mean	Description
The system is working properly, maintaining specified temperature.	4.45	Strongly Agree
It can set maximum and minimum temperature, hatch date, and number of rotations.	4.45	Strongly Agree
It can send SMS updates to the specified number of the operator/user.	4.45	Strongly Agree
It follows the number of rotations set by the operator/user.	4.45	Strongly Agree
The system power is fully functional ensuring no downtimes with the use of solar power.	4.45	Strongly Agree
Grand Mean	4.45	Strongly Agree

Table 7 present the results of evaluation given by the respondents for the functionality of Modern Eco- Smart Egg Hatcher. The results show a high overall mean rating of 4.45, implying that the system meets the required functionality. This implies that the overall functionality of the system is highly functional.

Table 8 **Reliability**

RELIABILITY	Mean	Description
The system is working properly, maintaining specified temperature.	4.7	Agree
It can set maximum and minimum temperature, hatch date, and number of rotations.	4.85	Agree
It can send SMS updates to the specified number of the operator/user.	4.95	Strongly Agree
It follows the number of rotations set by the operator/user.	4.95	Strongly Agree
The system power is fully functional ensuring no downtimes with the use of solar power.	4.85	Strongly Agree
Grand Mean	4.86	Strongly Agree

Table 9 presents the summary of Modern Eco- Smart Egg Hatcher. The summary demonstrates that the overall accuracy, effectiveness, functionality, and reliability of the system is highly satisfactory and indeed serve its intended purpose. The overall rating of the respondents suggests that the system provides a great performance and consistent results.

Table 9: **Summary of Modern Eco- Smart Egg Hatcher**

	Mean	Descriptive Interpretation
Accuracy	4.78	Strongly Agree
Effectiveness	4.84	Strongly Agree
Functionality	4.94	Strongly Agree
Reliability	4.86	Strongly Agree

Table 10 presents the overall result based on the survey conducted by the researchers among IT expert and end user. The result implies that the system meets the intended purpose. Based on the Likert scale, the results also shows that the evaluator were highly satisfied with the system's overall functionality.

Table 10: **Overall Result**

Evaluator	Weighted Mean	Verbal Description
IT Expert	4.86	Strongly Agree
End User	4.88	Strongly Agree

Findings

The researchers evaluate the Modern Eco- Smart Egg Hatcher's performance, accuracy, effectiveness, functionality and reliability in maintaining optimal conditions for egg hatching. The testing includes assessing key areas such as temperature control, humidity regulation, egg-turning mechanism, and the overall reliability of the system. The methodology involved integrating the incubator to ensure its sensors and controls were set according to specifications, followed by continuous monitoring of temperature and humidity over a 21-day period, simulating the entire incubation cycle.

During the testing phase, the Modern Eco-Smart Egg Hatcher maintained its operation and intended purpose, including the temperature control, humidity regulation, egg turning mechanism and sending of SMS notification.

To ensure that the Modern Eco- Smart Egg Hatcher meet its specific requirements, the researchers conducted a survey to the end user of the system to evaluate the system's accuracy, effectiveness, functionality and reliability using the survey questionnaire. The grand mean shows that the system's accuracy is 4.78, effectiveness is 4.84, functionality is 4.94, and reliability is 4.86, it implies that the respondents were highly commendable by the system's overall performance.

4. CONCLUSION

Overall, the Modern Eco Smart Egg Hatcher is a revolutionized tool for modern egg processing for poultry production. It works well following the embedded program. It also meets the beneficiaries' needs and requirements. By integrating smart features such as automated controls, real-time monitoring, and energy-efficient systems, it not only ensures optimal conditions for hatching but also reduces environmental impact. The combination of ease of use, eco-friendly design, and advanced functionality makes it an ideal solution for both hobbyists and professionals looking to improve their hatching success while embracing sustainability. This innovative system is set to redefine the future of incubation, offering a smarter, greener, and more reliable approach to egg hatching.

5. RECOMMENDATION

It is recommended that users adopt the Modern Eco Smart Egg Hatcher for a more efficient, eco-friendly, and user-friendly egg incubation experience. For optimal performance, users should regularly monitor and calibrate the system to ensure precise environmental conditions, particularly temperature and humidity. To maximize hatching success, users should follow maintenance guidelines, clean the system regularly, and utilize the provided training resources. Also maintain a close contact with the developer for clarifications regarding such cases encountered within the system.

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