AUTOMATIC TEMPERATURE MANAGEMENT IN BROODER AND ITS EFFECTS ON CHICKEN GROWTH AND BODY WEIGHT

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ABSTRAK

The poultry industry, which plays a crucial role in meeting global meat and egg production demands, can benefit from research on optimal environmental conditions, particularly temperature and lighting, for chicken productivity, with a focus on local breeds like Sentul chickens and the use of brooders for temperature control. This research aims to create an integrated temperature control system for chicken brooder using an Arduino Uno microcontroller and web-based monitoring, which will automate the control of brooder and provide continuous monitoring to enhance efficiency and productivity in poultry farming, particularly for Sentul chickens, by accurately measuring and monitoring microclimatic conditions, preventing measurement errors and fluctuations in temperature, and mitigating potential stress-related issues. The developed control system simplifies monitoring and control processes, eliminating the need for direct human intervention, and consists of hardware components such as temperature sensors, incandescent lamps, a microcontroller, and a router, and software components including programming the sensors, microcontroller, and website for data display, and a temperature control program developed using the Arduino programming language that effectively regulates the heating lamp based on temperature thresholds. The study showcases the effectiveness and academic relevance of utilizing Arduino-based technology and web-based monitoring systems in poultry farming, providing valuable insights for chicken farmers and serving as a reference for future development of temperature control devices, ultimately enhancing the efficiency and productivity of Sentul chicken production and benefiting the local community and the poultry industry.

Keywords: Arduino uno, chicken brooder, day-old chick, openwrt, temperature management

1 INTRODUCTION

The poultry industry, including the notable Sentul chicken breed from Ciamis, plays a vital role in meeting global demands for meat and eggs, with Sentul chickens prized for their unique greyish feathers tinged with red-gold, exceptional egg and meat quality, and contribution to local income, yet achieving their full potential requires optimal production conditions, notably regarding environmental factors like temperature and lighting which significantly influence chicken productivity, particularly during the starter phase when young chickens lack permanent feathers and struggle to regulate body temperature effectively. Therefore, maintaining an optimal temperature ensures their well-being and growth [1], [2]. Brooders, artificial heat sources, are commonly used by farmers to provide the necessary warmth that help create a suitable thermal environment, but their control is usually manual [3].

In addition to temperature, adequate lighting is essential for the growth and development of chickens. [4] emphasised that brooding chickens require sufficient illumination to promote weight gain. [5] demonstrated that chickens exposed to 40 lux of light exhibited higher activity levels at feeding areas than those exposed to 1 lux, 10 lux, or 20 lux. Therefore, controlling temperature and lighting conditions is crucial during brooding to ensure optimal growth and performance. Implementing microcontroller-based automatic control systems integrated with web-based monitoring can enhance efficiency and productivity in poultry farming by simplifying monitoring and control processes, particularly in areas such as controlling brooders for chickens, thereby eliminating the need for direct human intervention [2], [3].

Accurate measurement and monitoring of microclimatic conditions, especially air temperature within the chicken brooder, are essential for optimizing chicken growth, as microclimatic information directly informs subsequent actions aimed at ensuring optimal chicken development [4], [6]. Ensuring accurate measurements to mitigate stress from temperature fluctuations in the brooder is crucial, and leveraging this microclimate data for automatic temperature adjustments via an Arduino UNO microcontroller integrated with web-based monitoring enhances efficiency and optimal conditions, thus, this study aims to design a temperature control system for chicken brooder, involving processing sensor data and visualizing it on a dedicated webpage [6], [7]. The system's design will address the lack of a reliable control and monitoring system to maintain stable temperature levels for Sentul chickens in the poultry research facility of the Faculty of Animal Husbandry, Universitas Padjadjaran. The specific objectives of this research are: designing a brooder control system to meet the temperature and lighting requirements for chickens during the starter phase, developing a web-based monitoring system to facilitate the supervision of the brooder's performance, and assessing the impact of the control system on the weight gain of chickens.

This research is expected to have both practical and academic significance. From a practical perspective, the findings will provide valuable information for chicken farmers regarding using Arduino-based technology in controlling air temperature and implementing web-based monitoring systems. This research aims to solve the challenges associated with temperature measurement and control for chicken rearing. From an academic standpoint, this study can serve as a reference for further developing temperature control devices, particularly brooders, in poultry farming. By addressing these objectives, this research will contribute to advancing poultry farming practices and enhancing the overall efficiency and productivity of Sentul chicken production.

2 RESEARCH METHODOLOGY

The research methodology discusses various tools, instruments, and software used in the study. Electronic tools such as incandescent lamps, temperature sensors, a router, cables, a microcontroller, a USB flash disk, and a USB hub are utilised to provide heat, detect temperature, establish networking, and facilitate electronic connections. Measuring instruments like a thermometer, stopwatch, multimeter, and measuring tape are employed for temperature, timing, voltage/current/resistance, and distance measurement, respectively. Supporting equipment includes a brooder box for housing the chickens, a notebook for data processing, and a calculator for data calculations. Software tools like Arduino IDE, Fritzing, Putty, WinSCP, and MiniTool Partition Wizard Server are employed for programming, circuit sketches, router programming, file transfer, and memory expansion.

The research method employed in this study is engineering, applying scientific knowledge to design a system that meets specific requirements, with the procedure consisting of several stages: problem identification, literature review, data collection, functional design, structural design, control device creation, and testing [8], [9]. The initial stage of the design process, involving the identification of brooder box and chicken needs as well as the temperature control problem within it, is followed by identifying potential solutions outlined in the device design criteria, which are then translated into hardware and software by integrating electronic components and source code to control the microcontroller, followed by device accuracy and functionality testing [2], [9]. The experimentation phase begins by identifying the problem through preliminary research and interviews with chicken experts, followed by a literature review to find the most feasible solutions and establish the necessary components and design criteria for building the device, and then proceeds to test two brooder boxes, one manually measured with a thermometer and the other automatically with a microcontroller, to determine if consistent temperature control, real-time display, successful data reception and transfer, and continuous data acquisition can be achieved.

The working mechanism of the device involves the LM35 sensor reading the brooder's temperature, the data being processed and transferred through the microcontroller, OpenWRT, Python, and MySQL, and finally displayed on the website. Operators view the displayed temperature data, and the brooder operates accordingly to maintain the desired temperature range. The hardware design includes the design of an LM35 sensor circuit, which serves as a temperature sensor. The LM35 sensor has three pins and requires a 4-30 V DC voltage [10]. The circuit diagram of the LM35 sensor with the Arduino Uno microcontroller can be seen in Figure 1.

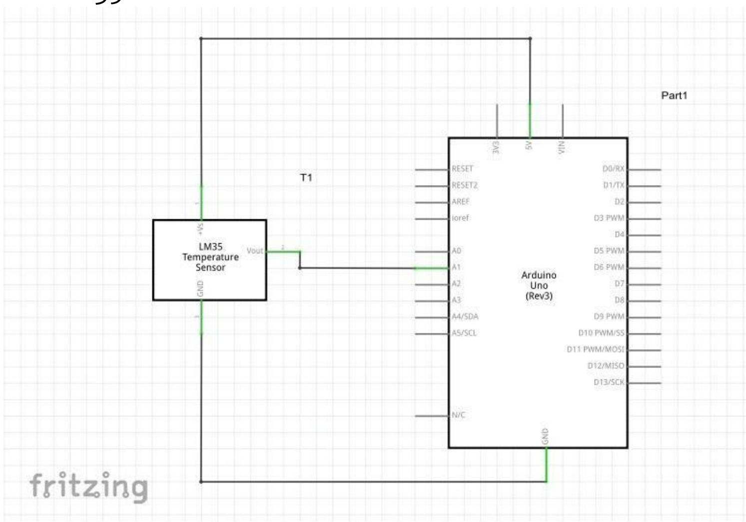


Figure 1: LM35 Sensor Circuit Design

In this design, two incandescent lamps serve as heat sources for the chickens in the brooder box, operating based on parameters from the LM35 sensor input to the Arduino, with the control device assembled by integrating all electronic components into a single system as shown in Figure 2.

The router captures Wi-Fi signals and sends temperature data to be displayed on the website. The TP-Link MR-3020 router is used, which is converted to OpenWRT and functions as a mini-computer. A flash disk increases the router's program storage and data memory capacity. The router is connected to the Arduino UNO via a USB hub and utilises Wi-Fi or LAN signals to send and display the temperature readings on the website.

The software design involves programming the LM35 sensor, router (OpenWRT), and a microcontroller with a relay for actuator control. The programming uses Arduino IDE software and other tools such as WinSCP and Putty for OpenWRT. The programming language is a simplified version of the C programming language, facilitated by the Arduino library [11]. The program on the Arduino UNO microcontroller reads the temperature data from the LM35 sensor. It is programmed with temperature parameters for the air heated by the incandescent lamps. When the temperature reaches the optimum level, the larger lamp turns off and a smaller lamp turns on. If the temperature falls below the minimum value, the lamp turns on again to increase the temperature. Therefore, the operator only needs to monitor the temperature condition in the chicken brooder without manually sending commands to control the actuators.

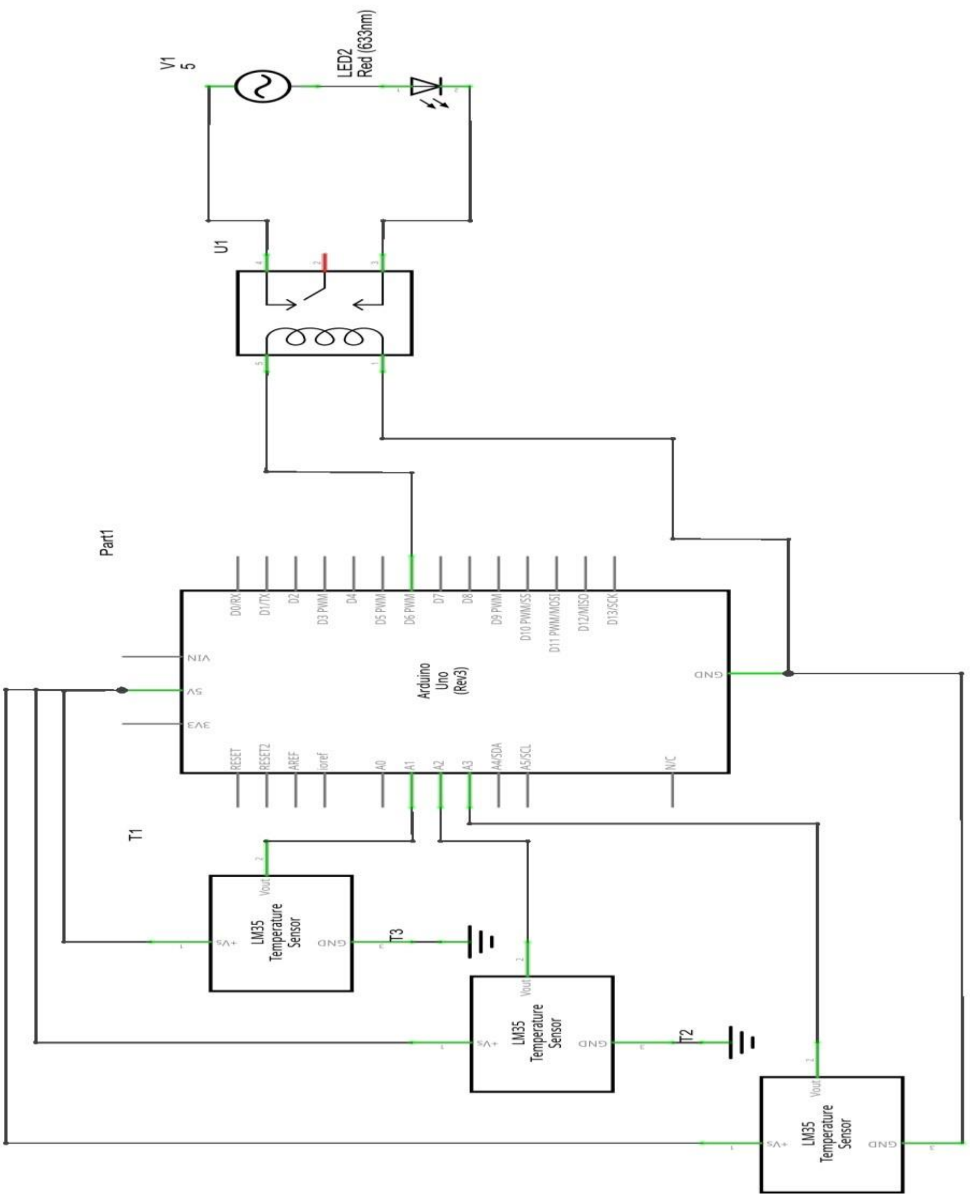


Figure 2: Overall Circuit Design

Tests were conducted to ensure temperature measurement accuracy, sensor sensitivity, and temperature control automation operation, with data collected from the temperature sensor processed and analyzed using programming software such as the Arduino IDE and Python, captured every minute, and stored in a MySQL database; analysis involved calculating the average temperature of the three LM35 sensors to determine the overall temperature in the brooder box, real-time visualization of temperature data on a website created using PHP and HTML, and evaluating the system's performance by comparing the collected temperature data with ideal temperature criteria to ensure proper functionality.

The validity of the results was tested through repeated testing to ensure consistency in temperature measurements, sensor calibration for accurate readings, external verification using an external thermometer, and visual observations to ensure that the temperature set by the system supports optimal growth and development. Following the completion of device testing, chick weight data was collected and subjected to descriptive statistical analysis, then compared with that of chicks in a conventional brooder to determine the more optimal method for maintaining brooder temperature and increasing chick weight, aiming to provide a reliable solution for temperature control in brooder boxes and improve the efficiency and productivity of Sentul chicken farms.

3 RESULTS AND DISCUSSION

The Brooder used in the study is a box-type brooder measuring 66 cm x 105 cm with a height of 33 cm. It is equipped with two 100-watt incandescent lamps as the heat source, and it includes feeding and drinking areas for the chicks. Figure 3 shows the Brooder Box before modification.

Figure 3: The Brooder Box before modification.

To address the issue of excessive heat and potential heat stress for the chicks, one of the 100-watt lamps was replaced with a 40-watt lamp. The decision to choose a 40-watt lamp was based on previous trials and errors, as the initial 15-watt lamp did not provide the ideal temperature for the chicks, causing them to feel cold and affecting their activities. After several experiments and lamp replacements, it was determined that the 40-watt lamp was the most suitable, as the chicks were able to engage in their activities properly.

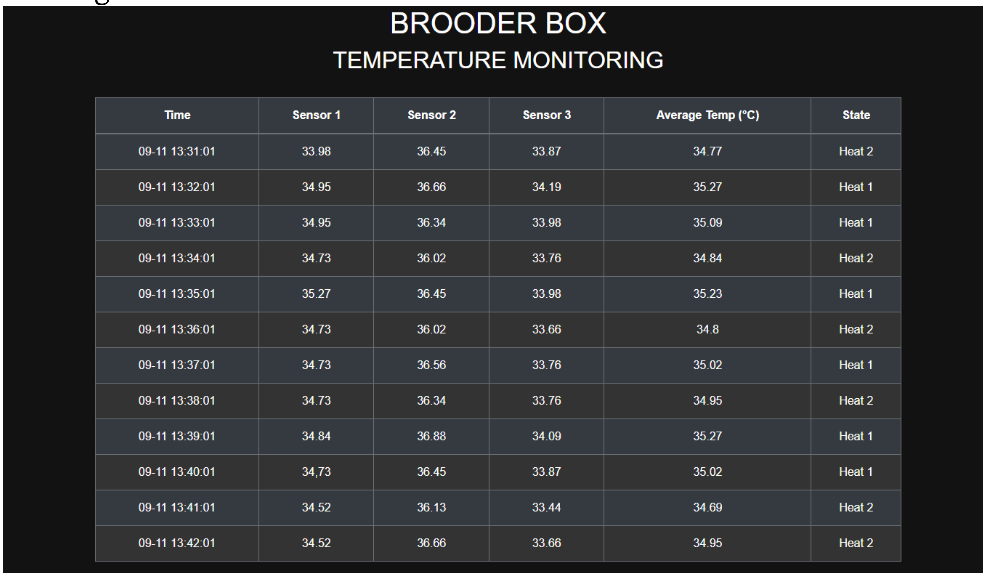
Additionally, three LM35 sensors were installed in the brooder to monitor temperature changes. A control system box was also added, consisting of a router, flash drive, breadboard, and Arduino UNO microcontroller. Figure 4 shows the Brooder Box, with the control system box and its components after modification.

Figure 4: The Brooder Box after modification

The temperature control program was developed using the Arduino IDE programming language, which can be downloaded from the Arduino website. The program controls the heating lamp, turning it on when the temperature is below 35°C and off when it exceeds 35°C. The complete code is presented in Figure 5, showcasing the Arduino IDE interface.

Figure 5: Arduino UNO Code and Algorithm

A website was created for temperature monitoring using PHP and HTML programming languages. The website displays information such as date and time, temperature readings from the three sensors, average temperature, and the status of the actuator. Figure 6 illustrates the layout of the monitoring website.



BROODER BOX

TEMPERATURE MONITORING

Time	Sensor 1	Sensor 2	Sensor 3	Average Temp (°C)	State
09-11 13:31:01	33.98	36.45	33.87	34.77	Heat 2
09-11 13:32:01	34.95	36.66	34.19	35.27	Heat 1
09-11 13:33:01	34.95	36.34	33.98	35.09	Heat 1
09-11 13:34:01	34.73	36.02	33.76	34.84	Heat 2
09-11 13:35:01	35.27	36.45	33.98	35.23	Heat 1
09-11 13:36:01	34.73	36.02	33.66	34.8	Heat 2
09-11 13:37:01	34.73	36.56	33.76	35.02	Heat 1
09-11 13:38:01	34.73	36.34	33.76	34.95	Heat 2
09-11 13:39:01	34.84	36.88	34.09	35.27	Heat 1
09-11 13:40:01	34,73	36.45	33.87	35.02	Heat 1
09-11 13:41:01	34.52	36.13	33.44	34.69	Heat 2
09-11 13:42:01	34.52	36.66	33.66	34.95	Heat 2

Figure 6: Monitoring Website Interface

The website features hover functionality to facilitate reading, and the table headers are designed to follow the user's scrolling. It is recommended to access the website using the Google Chrome web browser for optimal performance. The temperature measurement was conducted using three LM35 sensors, and the average value was obtained to determine the overall temperature of the brooder box. The measurements were taken continuously for 24 hours and inputted into a monitoring website. The temperature data collected during the measurements provided real-time information on temperature changes every minute. This information allows the operator to identify periods that require higher or lower temperatures.

Several challenges were encountered during the temperature measurement process. One of the main obstacles was the inconsistency in temperature, which resulted from variations between the experimental location and the research setting. Inappropriate temperature conditions had adverse effects on the health and behaviour of the chicks. Cold temperatures caused the chicks to gather and huddle together for warmth, leading to chicks being crushed and dying [12]. Additionally, cold temperatures hindered feeding and affected the optimal growth of the chicks [13]. The incandescent bulb's wattage was adjusted to address the inadequate temperature issue. Replacing the 15-watt and 75-watt bulbs with 40-watt and 100-watt bulbs successfully resolved the temperature deficiency, maintaining the required temperature range of 32°C to 35°C.

Another challenge encountered was the presence of noise in the temperature readings. Noise refers to unwanted signals or disturbances in an electronic system. In this study, significant levels of noise were observed during the temperature data collection [14]. The noise manifested as sudden and drastic fluctuations in temperature within a short period, even though such variations did not occur. This noise issue was mitigated by improving the circuitry to eliminate visible noise.

The lack of an internet connection posed difficulties in data collection during the initial days of the study. The research was conducted in a remote location without an available internet network. This absence of internet connectivity disrupted data collection, as the system's time indicator would revert to the last time the router was powered on after a restart. Consequently, duplicate timestamps appeared in the database, leading to errors due to the primary key configuration for time management. This challenge was addressed by adding a Mini WiFi Router (Mi-Fi) as an alternative internet source. Signal issues arose after resolving the internet connectivity problem with the Mi-Fi device. Despite the generally strong signal strength of the Mi-Fi used, occasional signal disruptions occurred, affecting the monitoring process. No specific measures were taken to address this challenge, as the signal conditions eventually stabilised, allowing continuous monitoring to proceed.

The presence of heat leaks posed another obstacle. Heat leaks were observed due to gaps in the brooder box. These gaps allowed heat exchange between the brooder box and the external environment, compromising the brooder box's ability to maintain the required temperature for the chicks. To mitigate this issue, some of the gaps in the brooder box were sealed, preventing heat exchange with the surrounding environment and ensuring temperature stability. Another factor contributing to heat exchange with the environment was the litter container made of zinc. Zinc is a good conductor of heat, and in cases where the environmental temperature significantly differed from the brooder temperature, zinc acted as an equaliser, causing a decrease in the brooder temperature to balance it with the surroundings [15]. However, no further action was taken to address this issue, as the previous gap-sealing measures were sufficient to minimise heat leaks. Additionally, preliminary testing of alternative materials to replace zinc in the litter container was suggested for future improvements.

Table 1. Body Weight of 12-Day-old Chickens in the Early Stage Study

Chicken	Weight (gr)	
	Automatic Brooder	Conventional Brooder
1	57	38
2	55	51
3	32	39
4	33	40
5	43	61
6	36	52
7	34	48
8	47	40
9	32	45
10	34	0
11	31	0
12	25	0
13	27	0
14	34	0
15	32	0
16	37	0
17	40	0
18	36	0
Average	**36.94**	**46.70**

The growth of chickens is a crucial parameter as it determines the body weight achieved within a specific time frame [16]. Table 1 presents the body weights of chickens at 12 days of age using automatic and conventional brooders. The average weight of chickens in the automatic brooder was 36.94 grams, while in the conventional brooder, it was 46.70 grams. The lower weight in the automatic brooder was attributed to various constraints during the initial research phase, as discussed earlier, which resulted in the automatic brooder not reaching the ideal temperature required for chicks, which is 32°C - 35°C, but only reaching 28°C - 30°C. As a result of not attaining the ideal temperature inside the brooder, the chicks did not grow optimally, resulting in lower body weight [17].

Table 2. Body Weight of 7-Day-old Chickens in the Final Stage of Research

Chicken	Weight (gr)	
	Automatic Brooder	Conventional Brooder
1	40	27
2	36	28
3	49	36
4	34	36
5	36	32
6	47	27

Chicken	Weight (gr)	
	Automatic Brooder	Conventional Brooder
7	46	38
8	40	44
9	31	42
10	46	45
11	43	36
12	44	40
13	45	47
14	45	43
15	48	-
16	45	-
17	46	-
18	42	-
19	42	-
20	37	-
Average	**42.10**	**37.21**

Table 2 displays the body weights of chickens at seven days of age in the final research phase, where the average weight was 42.10 grams in the automatic brooder that provided the appropriate temperature (32°C - 35°C) for optimal growth, compared to 37.21 grams in the conventional brooder, indicating that when functioning correctly, the automatic brooder can provide a suitable temperature environment for chicks, resulting in better growth and higher body weights.

4 CONCLUSIONS

The development of an Arduino UNO microcontroller-based automatic chicken brooder temperature control system, integrated with web-based monitoring, effectively maintains the desired temperature range for optimal chick growth and development, surpassing manual control used by conventional brooders, as demonstrated in testing where the LM35 temperature sensor accurately measures and controls the brooder temperature, displays real-time data, and enables remote monitoring, reducing the need for workers nearby, with experimental results confirming its effectiveness in maintaining stable temperature environments, resulting in improved chicken growth and body weights compared to conventional methods, offering advantages such as improved temperature regulation, stress reduction, increased efficiency, remote monitoring, data logging, and significant advancement in poultry farming practices, thus providing a reliable and efficient means of maintaining optimal temperature conditions for enhanced productivity and profitability in poultry farming operations.

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