Automatic Feeding of Laying Hens Based on Real-Time Clock

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***Abstract*—The process of feeding laying hens in large quantities and on time manually will experience difficulties. The manual feeding method makes feeding less effective and efficient. A real-time clock (RTC)-based automated feeder for laying hens has been designed in this research. The purpose of designing a laying hens feeder is to assist breeders in automatic feeding management. This tool works by automatically feeding laying hens, which will be active at predetermined time intervals with Arduino Uno as the main system controller. Meanwhile, the RTC provides the time reading by Arduino Uno displayed on the LCD. Then, the Stepper motor functions as a feeding collection actuator and the Servo motor as a feeding valve actuator. This study revealed that the error value of one-week feeding in three feeding slots for three laying hens was 1.66% and in two feeding slots for two laying hens was 0.86%.**

Keywords—Real-Time Clock, Arduino Uno, Laying Hens, Automatic.

I. INTRODUCTION

In the conventional process of raising poultry, especially laying hens, they expect technological advances. The development of increasingly advanced technology is expected to increase the ease in sharing aspects of life and human needs [1].

From small to large industrial scales, lying hens are frequently found in various regions, especially in Java, Indonesia [2]. Unlike the European Union, from 2012 onwards, laying hens in conventional battery cages has been banned due to the development of salmonella that attacks laying hens. Only non-cage systems such as birdcages, cage systems, free cages, and organic systems are allowed. It aims to improve the welfare of laying hens [3].

Each battery cage can generally accommodate up to ten laying hens. The average allotment of room per hen in battery cages is usually less than A4 paper and has sufficient height when the hen is standing [4]. Manual feeding management requires more time and effort. Feeding arrangement is part of the maintenance system management that affects production yields because it requires the highest cost of production in a chicken farming business.

Small farmers want automatic feeding technology at a low cost for their farming. The chicken feeding arrangement can be carried out automatically by setting the feeding time interval to meet chicken feed needs.

The authors utilized some references from previous studies as follows. Ariyanti et al. (2019) conducted a study on "Modification of Automatic Chicken Feeder Based on ATMEGA 3285 Microcontroller" [5]. The study designed an automatic feeder for broiler chickens by producing an effective and efficient work system. Pradiptya (2018) conducted research on "Prototype of Automatic Feeding and Drinking System in Chicken Cages Using PLC with HMI Monitoring". The research designed a prototype tool used for feeding broiler chickens automatically using a PLC as the system controller [6].

Yuda (2016) studied "Automatic Chicken Feeding and Drinking Equipment in Closed System Chicken Cages Based on RTC DS130". The study designed a tool for feeding and drinking broiler chickens in automatically closed cages with RTC DS130 as the provider of the feeding time reading by the tool system [7]. Syafitri (2016) investigated "Automatic Broiler Chicken Feeding Systems Based on the Internet of Things". The study designed an automatic broiler feeding system using the internet of things which can be set and controlled via an internet connection [8].

Nasution et al. (2015) conducted a study on "Design of Automatic Feeding Equipment and Temperature Control for Broilers Based on Programmable Logic Controller in Closed Cages". The study designed an automatic feeding and temperature control device for broilers in closed cages [9].

Dada et al. (2018) researched "Arduino Uno Microcontroller Based Automatic Fish Feeder". The study designed an automatic fish feeder using a feedback system to control the feeding quantity in the aquarium [10].

Overall, the previous studies aim to provide convenience for chicken farmers to save on maintenance costs by designing tools applicable for chicken farming with conventional systems at low costs. This research designed an automatic feeder for laying hens by determining the time interval for feeding. This automatic feeding system can save workforce, time, and cost in rearing laying hens. Testing and analysis were performed on the system designed.

II. METHOD

This research went through several stages, as illustrated in the flowchart Figure 1. Fig. 1 demonstrates that the research began by studying the problems experienced by laying hens farmers. After that, the researchers looked for reference sources, designed a system, made the tools, and tested them by analyzing the data results. The last step is concluding the research.

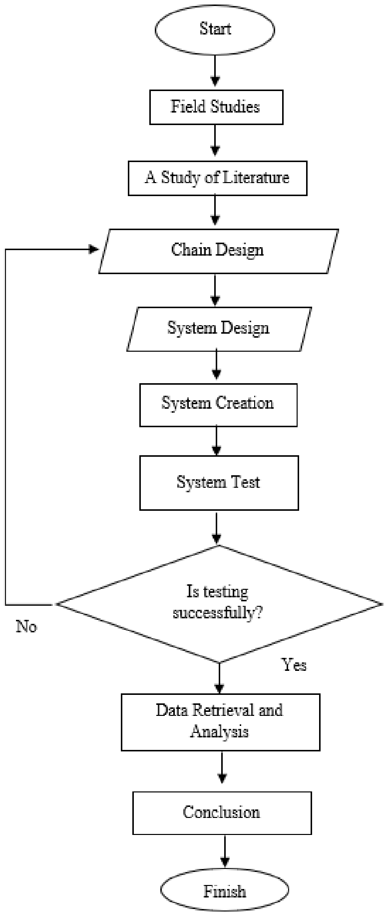

Fig. 1. Research Flowchart

A. Materials and Tools

Several instruments consisting of tools and materials are required to carry out research on the manufacture of automatic chicken feeders for laying hens. Table 1 displays the materials, and Table II depicts the tools used in this study.

TABLE I. MATERIALS

No	Material	Total
1	Arduino Uno	1
2	Real Time Clock DS3231	1
3	Servo Motor	1
4	Nema 17 Stepper Motor	1
5	TB6600 Stepper Motor Driver	1
6	Limit Switch	1
7	Liquid Crystal Display (LCD)	1
8	I2C	1
9	Male dan Female Cable	-
10	Project Board	1
11	12 Volt Adapter	1
12	Belt	1
13	Pulley	2
14	Hollow Alumunium	3
15	Acrilik Box	1

The design required several materials or components, such as the Arduino Uno microcontroller, functioning as the main controller in the system being made. Other supporting components comprised an RTC DS3231 as a time provider for reading by Arduino for the feeding schedule, a Driver TB6600 as a pulse signal controller regulating the speed and position of the stepper motor, a Stepper motor used as an actuator to distribute feed through the rail as a path, a Servo motor used as an actuator to remove the feed from the feed container, a Limit Switch as a motor position reader sensor, and an LCD as a display of information on the system when the sketch program has been uploaded.

TABLE II. TOOLS

No	Name	Type
1	Arduino Ide	Software
2	Fritzing	Software
3	Multimeter	Hardware

In this study, the authors used several tools such as Arduino Ide, Fritzing, and Multimeter.

B. Hardware Design

Before making the automation tooling system (ATS) for feeding laying hends based on the real-time clock (RTC), a description was required to prevent the hardware manufacture from experiencing problems. The following figure is an overview of the hardware design.

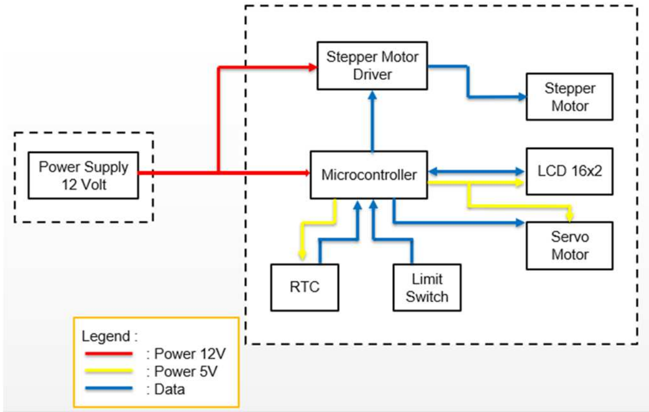

Fig. 2. Tool System Diagram

Fig. 2 illustrates the design diagram of an RTC-based feeding system for laying hens. The power source of this tool comes from the adapter. There is a Limit Switch as a motor position sensor stepper. Then, the RTC functions as a time provider for reading by Arduino for setting the feeding time interval, displayed on the 16 x 2 LCD driver TB6600 to activate the motor holder Stepper as an actuator by moving the feed. Meanwhile, the Servo motor functions to open the feed faucet.

1) Tools Design: Fig. 3 exhibits the design of the RTC-based automation tool for feeding laying hens. This design is used to facilitate the manufacture of tools to minimize errors in the feeding system. The information in the image is as follows:

Length	: 100 cm
Width	: 50 cm
Height	: 50 cm

Fig. 3. Design of the Feeding Automation Tool

2) The Whole Schematic of The Tool: The information in the image is depicted in Fig. 4.

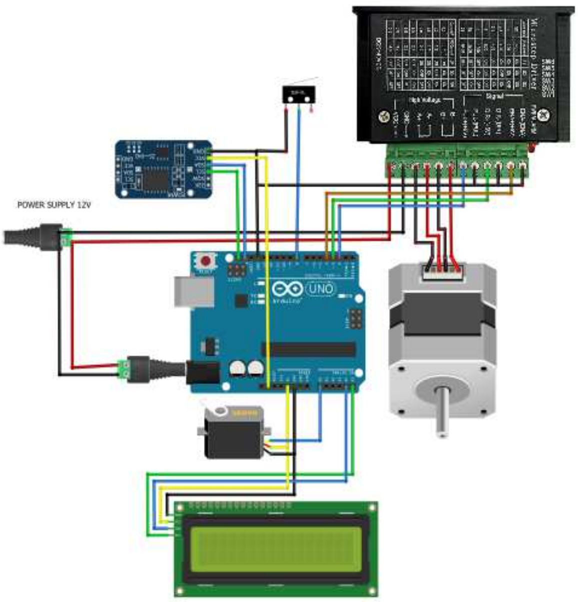

Fig. 4. Overall Schematic of the Tool

3) Software Design: The software design was conducted by entering the sketch program on the Arduino Uno microcontroller board, controlling the entire system. This programming utilized the Arduino IDE to write a sketch program and uploaded it to the Arduino Uno board. The program flow diagram is demonstrated in Fig. 5.

Fig.5 presents that the program begins with the start to run the program. The next step is to read the feed reservoir's position, whether in the "home" position or not, using the limit switch as the feed reservoir position sensor. When the Arduino time reading from the RTC displayed on the LCD shows at 07.00 and 15.00, the system works and distributes feed by activating the stepper motor to move the feed container on the rail as the feed distribution line. When the mileage of the stepper motor has reached its point, the stepper motor stops.

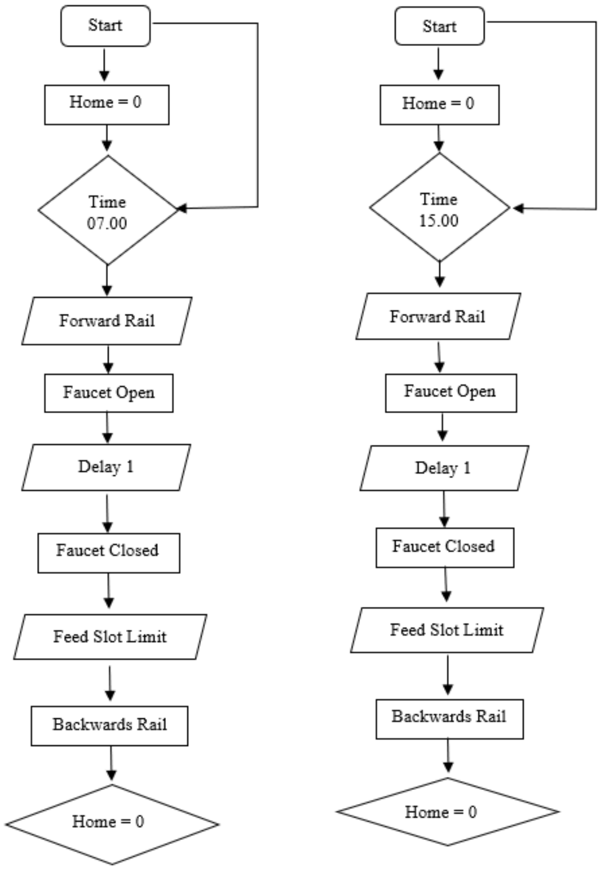

Fig. 5. Flow chart of Program

Then, it opens the feed valve by adjusting the opening angle set. The length of opening time to release the feed is 40% in the morning and 60% in the afternoon, where the setting regulates the quantity of feed released. When the time length to open the servo motor feed valve has been met, the servo motor closes again. Then, the system continues to run until the limit has been determined in the sketch program. When the number of feeding slots has been met, the stepper motor shifts the feed reservoir back to its original position or standby.

4) Sketch Design: The software design functions as a command on the system containing a sketch program using the Arduino Uno.

a) LCD Program: In the sketch program, the LCD functions to display the information output of the system state.

b) RTC Program: In the sketch program, the RTC functions to provide time for reading by Arduino Uno.

c) Servo Motor Program: In the sketch program, the servo motor functions to adjust the opening time and the width of the opening angle.

d) TB6600 Driver Program: In the sketch program, TB6600 controls the motor stepper by providing periodic "signal" pulses.

e) Limit Switch Program: In the sketch program, the Limit Switch functions as the position sensor of the stepper motor when it is not in its proper position.

5) Testing: Tests were carried out on the system to determine whether it has experienced a voltage drop or not. The authors' tests are as follows:

Arduino Testing, it aims to ensure that Arduino is ready to be used for the main controller of the instrument system being made. It was conducted by inputting the program by uploading it to the Arduino and measuring the Arduino voltage before and after the operation. *LCD Testing:* It aims to determine that the voltage supply on the LCD is fulfilled to operate it. It was carried out by measuring the supply voltage for the VCC and GND pins on I2C.

RTC Testing, It aims to determine that the supply voltage on the RTC has been fulfilled. It was performed by measuring the supply voltage at the VCC and GND pins on the RTC.

Servo Motor Testing, it aims to determine that the servo motor can work properly. It was carried out by measuring the voltage supply in the voltage supply chapel and the GND cable and measuring the rotational angle of the servo motor. *Driver TB6600 Testing,* it aims to determine that the TB6600 driver with a Stepper Motor can work appropriately by measuring the voltage supply at the VCC and GND driver terminals of the TB6600 and the windings A and B terminals of the motor stepper.

Limit Switch Testing: It aims to determine the work function of the limit switch by testing the function of the limit switch position sensor connected to pin eight and GND of the Arduino board.

Power Supply Testing, it aims to determine that the supply voltage supplied meets the needs of the voltage on the system creating the tool. It was performed by measuring the input and output voltages on the power supply.

Overall Testing, it aims to ensure that the entire tool system can work properly. It was carried out by uploading a sketch program inputted with setpoints according to the number of feeding slots on the Arduino Uno connected to the entire set of tools.

6) Data Analysis: A descriptive analysis technique was applied to analyze the results. The average percentage data (error) generated were then analyzed to determine the error value and the factors causing it. The data were generated from testing the tools using the feed tap opening time of 450 ms at 07.00 and 550 ms at 15.00 with an opening angle of 20° in feeding three hens divided into three feeding slots.

TABLE III. THE ANALYSIS OF THE RESULT DATA EMPLOYED THE MEAN PERCENTAGE EQUATION. THE AVERAGE PERCENTAGE (ERROR) IS THE TESTING RESULTS OF FEEDING AT 15.00 (AFTERNOON)

Day	**Time**	**Set point (gr)**	**Feed Out (gr)**			**Average (gr)**	**Error (%)**
			1	**2**	**3**		
Mon	15.00	45	81	66	68	71.67	6.97
Tue			77	65	72	71.33	6.46
Wed			56	71	67	64.67	3.47
Thu			66	67	74	69	2.98
Fri			84	71	73	76	13.43
Sat			67	76	63	68.67	2.49
Sun			66	62	59	62.33	6.97
Total			1451				
Average						69.10	6.11

Then, in the second experiment, the quantity of the feed tap opening time was 650 ms at 07.00 and 850 ms at 15.00 with an opening angle of 20° in feeding four hens divided into two feeding slots. Overall data results obtained from testing the three feeding slots for three hens and two feeding slots for four hens using the standard value minus the value of one-week data. It aims to discover the error value and the factors causing it to determine the performance of the tool.

Formula (1) was employed to obtain the percentage value (error) from the data results.

$$E\% = \frac{Value\ Standard - Monetary\ Value}{Value\ Standard} \times 100\% \quad (1)$$

The error in each table was calculated by weighing the feed coming out in each feed slot using the percentage formula. It aims to obtain the average (error) or feed out every day and every week from the total feed given.

III. RESULT AND DISCUSSIONS

This section contains the testing results of electronic devices and a sketch program aiming to determine whether the components can function properly or not.

A. Overall Testing

The overall testing employed a scale by measuring the weight of the feed coming out of each feed slot and then comparing them with the standard value of chicken feed needs. It was conducted to determine the percentage error of comparing the results of measuring the weight of the outgoing feed with the standard value of chicken feed needs. The steps taken in the overall testing are as follows:

- Giving setpoints according to the setting
- Weighing the results of the feed coming out and then comparing them with the standard value of laying hens' feed requirements
- Analyzing the whole system

1) Testing of Three Feeding Slots: The following are the feeding test results at 07.00 (morning) for three hens divided into three feeding slots with a distance of each slot of 20 cm. The test results are depicted in Tables III-VI.

TABLE IV. TESTING RESULTS OF FEEDING AT 07.00 (MORNING)

Day	**Time**	**Set point (gr)**	**Feed Out (gr)**			**Average (gr)**	**Error (%)**
			1	**2**	**3**		
Mon	07.00	45	47	53	48	49.33	9.62
Tue			41	46	42	43	4.44
Wed			45	39	43	42.33	5.93
Thu			46	40	52	46	2.22
Fri			48	49	39	45.33	0.73
Sat			52	43	42	45.67	1.48
Sun			41	46	38	41.67	7.55
Total			940				
Average						44.76	4.6

TABLE V. TESTING RESULTS AT 07.00 (MORNING) WITH A DELAY OF 450 MS

Day	Time	Set point (gr)	Distance per slot (cm)	Rotated Angle and Motor Delay			Avg. Feed Out (gr)
				CW	Delay	CCW	
1	07.00	45	20	105°	450 ms	125°	49.33
2							43
3							42.33
4							46
5							45.33
6							45.67
7							41.67
Average per week							44.76

TABLE VI. TESTING RESULTS AT 15.00 (AFTERNOON) WITH A DELAY OF 550 MS

Day	Time	Set point (gr)	Distance per slot (cm)	Rotated Angle and Motor Delay			Avg. Feed Out (gr)
				CW	Delay	CCW	
1	15.00	67	20	105°	550 ms	125°	71.67
2							71.33
3							64.67
4							69
5							76
6							68.67
7							62.33
Average per week							69.10

TABLE VII. AVERAGE TESTING RESULTS PER WEEK

No	Time	Setpoint (gr)	Average Feed Out (gr)	Error (%)
1	07.00	45	44.76	0.53
2	15.00	67	69.1	3.13
Total		112	113.86	1.66

Table VII displays that the average feed needs per week per hen tested at three feeding slots indicates that the system can work properly. It can be proven from the average error of one-week feeding of 0.53% at 07.00 and 3.13% at 15.00. Moreover, the overall error in the average feed out in one week is 1.66%, implying that the error can still be tolerated.

2) Testing of Two Feeding Slots: The following tables demonstrate the feeding testing results at 07.00 (morning) for four hens, divided into two feeding slots with a distance of 30 cm each slot.

TABLE VIII. TESTING RESULTS OF FEEDING AT 07.00 (MORNING)

Day	Time	Set point (gr)	Feed Out (gr)		Average (gr)	Error (%)
			1	2		
Mon	07.00	90	105	83	94	4.44
Tue			83	76	79.5	11.66
Wed			81	104	92.5	2.77
Thu			91	95	93	3.33
Fri			75	84	79.5	11.66
Sat			96	88	92	2.22
Sun			89	93	91	1.11
Total			1243			
Average					88.78	5.31

TABLE IX. TESTING RESULTS OF FEEDING AT 15.00 (AFTERNOON)

Day	Time	Setpoint (gr)	Feed Out (gr)		Average (gr)	Error (%)
			1	2		
Mon	15.00	134	127	132	129.5	3.35
Tue			134	131	132.5	1.11
Wed			129	127	128	4.47
Thu			134	137	135.5	1.11
Fri			139	140	139.5	4.1
Sat			140	127	134.5	0.37
Sun			130	137	133.5	0.37
Total			1864			
Average					133.28	2.12

TABLE X. TESTING RESULTS AT 07.00 (MORNING) WITH A DELAY OF 650 MS

Day	Time	Set point (gr)	Distance per slot (cm)	Rotated Angle and Motor Delay			Avg. Feed Out (gr)
				CW	Delay	CCW	
1	07.00	90	30	105°	650 ms	125°	94
2							79.5
3							92.5
4							93
5							79.5
6							92
7							91
Average per week							88.78

TABLE XI. TESTING RESULTS AT 15.00 (AFTERNOON) WITH A DELAY OF 850 MS

Day	Time	Set point (gr)	Distance per slot (cm)	Rotated Angle and Motor Delay			Avg. Feed Out (gr)
				CW	Delay	CCW	
1	15.00	134	30	105°	850 ms	125°	129.5
2							132.5
3							128
4							135.5
5							139.5
6							134.5
7							133.5
Average per week							133.28

TABLE XII. AVERAGE TESTING RESULTS PER WEEK

No	Time	Setpoint (gr)	Average Feed Out (gr)	Error (%)
1	07.00	90	88.78	1.35
2	15.00	134	133.28	0.53
Total		224	222.06	0.86

Table XII describes the average feed needs per week of two hens per cage slot tested on two feeding slots, implying that the system can work appropriately. It can be proven from the average error of one-week feeding of 1.35% at 07.00 and 0.53% at 15.00. Furthermore, the error of the one-week average feeding is 0.86%, signifying that the error can still be tolerated. The average error in the amount of feed coming out occurred because the texture of the feed was different, causing chokes and sometimes exceeding the standard value of hens' feed needs. The average error value from one-week data is 1.66% (Three Feeding Slots) and 0.86% (Two Feeding Slots).

Fig. 6. Overall Feeder Automation Equipment for Laying Hens

The authors tested the automation tool for laying hen feeders with intervals in the morning at 07.00 and afternoon at 15.00 for one week to collect data. Testing and analysis of the tool system aim to obtain data results used to determine the possibility of errors and anticipate future errors when the system operates. The analysis revealed that the errors could be corrected and anticipated.

IV. Conclusions

The automatic feeding system uses the Arduino component as the main controller. It contains the feeding system program, RTC DS3231 as the Arduino time reading input, an 16 x 2 LCD displaying system conditions, and a Limit Switch as a motor position sensor stepper with an actuator to shift the feed container using a motor. Moreover, a NEMA17 stepper rotates the speed and direction with the TB6600 driver, and the actuator drives the feed tap of a 180° servo motor with an open-angle and the amount of time it opens to adjust the amount of feed coming out. The average feed error removed from the one-week feed container unveiled that the results were tolerable. The automatic feeding system for laying hens could provide a one-week feed with an average error value of 1.66% for three feeding slots. On the other hand, the average error value for two hens in two feeding slots was 0.86%. Therefore, this study suggests adding a battery as a backup for the supply of the system voltage requirements when the supply is not met. Moreover, adding a feed limit sensor and buzzer as an indicator is necessary to anticipate that the feed runs out while the process is in progress.

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References

[1] Y. Shang, S. Kumar, B. Oakley, and W. K. Kim, "Chicken Gut Microbiota: Importance and Detection Technology," *Front. Vet. Sci.*, vol. 5, Oct. 2018, doi: 10.3389/fvets.2018.00254.

[2] Y. L. Henuk, D. Bakti, G. A. M. K. Dewi, and S. Y. F. G. Dillak, "Chickens Population and Production and Their Contribution to Human Population in Indonesia," no. October, pp. 19–21, 2016.

[3] J. Dewulf, S. Van Hoorebeke, and F. Van Immerseel, "Epidemiology of Salmonella infections in laying hens with special emphasis on the influence of the housing system," in *Improving the Safety and Quality of Eggs and Egg Products*, Elsevier, 2011, pp. 107–119.

[4] Compassion in World Farming, "About egg-laying hens | Compassion in World Farming." https://www.ciwf.eu/farm-animals/chickens/egg-laying-hens/ (accessed Sep. 25, 2021).

[5] M. Ariyanti, K. D., P, J., & Rais, "Modification of Automatic Chicken Feeder Based on ATMEGA 3285 Microcontroller," *J. Pendidik. Teknol. Pertan.*, vol. 5, no. 2, pp. 1–9, 2019.

[6] Pradiptya, "Prototype of Automatic Feeding and Drinking System in Chicken Cages Using PLC with HMI Monitoring," 2018.

[7] A. K. Yuda, "Automatic Chicken Feeding and Drinking Equipment in Closed System Chicken Cages Based on Rtc Ds130," *J. Tek. Elektro*, vol. 2, no. 2, pp. 1–36, 2016.

[8] R. Syafitri, "Automatic Broiler Chicken Feeding Systems Based on the Internet of Things," *J. Tek. Elektro*, vol. 7, no. 3, pp. 1–55, 2016.

[9] E. Nasution, A. K., Trisanto, A., & Nasrullah, "Design of Automatic Feeding Equipment and Temperature Control for Broilers Based on Programmable Logic Controller in Closed Cages," *Rekayasa dan Teknol. Elektro Ranc.*, vol. 9, no. 2, pp. 86–95, 2015.

[10] A. L. Dada, E. G., Theophine, N. C., & Adekunle, "Arduino UNO microcontroller based automatic fish feeder.," *J. Sci. Technol.*, vol. 19, no. 1, pp. 68–174., 2018.