DESIGN AND BUILD A POND TEMPERATURE CONTROL SYSTEM AND AUTOMATIC FEED FOR TILAPIA IN AQUAPONICS

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Abstract— Expansion of land causes the population and food needs to be unbalanced. One way to overcome this problem is aquaponic cultivation. Aquaponics is a modern practical farming system that integrates plant cultivation systems with the cultivation of aquatic animals. One of the success factors of aquaponics is temperature and automatic feeding of pond water. To get the right temperature for fish, temperature control can be done using the DS18B20 temperature sensor. When the fish pond temperature drops below 28°C, the heater will automatically turn on to raise the pond temperature, and when the pond temperature rises above 32°C, the peltier will light up and start lowering the fish pond temperature. Automatic feeding uses the Real Time Clock (RTC) module as a timer and a servo motor as the opening valve for the fish feed container. The results of this research obtained the relative growth rate (RGR) ratio of fish before and after the control system was installed was 7.14% and 11.2%, respectively. The feed conversion ratio (FCR) values of fish before and after the control system was installed were 12.50% and 21.07%, respectively. The plant growth rate before and after the control system was installed were 22.9% and 33.71%, respectively.

Keywords— Aquaponic, DS18B20 temperature sensor, motor servo

1. INTRODUCTION

Land transfers are currently used to build large buildings and expand human civilization. Land conversion has an impact on limited land area and the amount of water from various aspects, especially in agriculture [1]. The problem in cultivation activities, in addition to waste is the reduction of vacant land for activities cultivation and water resources[2]. Land use is increasing, while the availability of limited land area encourages land conversion from agricultural land to non-agricultural land. Agricultural land is becoming very scarce in urban areas. Meanwhile, the demand for food needs is increasing with the rapid increase in population. One alternative way to overcome this need is to use a large landless agricultural system, namely Aquaponics.

Aquaponics is a modern practical agricultural system that combines an integrated plant cultivation system with the cultivation of aquatic animals [3]. Aquaponics is one way to reduce water pollution produced by fish farming and is also an alternative to reducing the amount of water used for cultivation. Aquaponic technology is an alternative that can be applied to break the limitations of available water [1]. Water as a medium for fish cultivation is the main factor in determining fish breeding [4]. Therefore, it is important to analyse and know the various factors that can affect water quality and natural characteristics to provide a natural source of life for aquaculture carried out. To produce superior fish commodities, a system is needed to monitor and measure the quality of fish pond water and control feed in the aquaponics system. Pond temperature is one of the things that need to be considered so that fish grow well. Increasing and decreasing pond water temperatures that are erratic and not in accordance with the condition of the fish will cause the fish to have difficulty in the energy mobilization process and result in death in a short time [5]. A good livestock management system is the main factor in obtaining quality fish [5]. One of them is feeding which must be monitored so that it is given according to the frequency of feed needed by the fish, excess frequency of feeding will cause tilapia to get sick, even die [5].

Based on the problems described in the previous paragraph, this final project will design a more innovative aquaponics system. The system identifies feed control and temperature levels in pond water. Automatic feed control is set at the specified time using RTC. RTC (Real time clock) is an electronic clock in the form of a chip that can calculate time (from seconds to up to years) accurately and maintain and save the time data in real time[6]. Fish feeding was carried out at 08.00 am, 12.00 pm and 17.00 pm [7]. Feeding fish by 3% of the total weight fish body [8]. The frequency of feeding depends on the condition of the fish and the environment [9]. In general, feeding is done 2-3 times per day [9]. When the temperature of the fish pond drops to about 28°C and below, the heater will automatically turn on to raise the temperature of the pond, and when the temperature of the pond rises, the peltier will light up and start lowering the temperature of the fish pond. The importance of continuous monitoring of water quality and water temperature in the success of Aquaponics, it is necessary to design a control system and water temperature monitoring system that can be controlled automatically. The water quality parameters controlled in this study consisted of feed and temperature control. The research conducted can be expected to provide better changes to the aquaponics system.

2. PREVIOUS RESEARCHES

The journal entitled Analysis of Environmental Characteristics of Water and Ponds in Supporting Fish Cultivation was made by Neny Rochyani, a teaching staff at the Faculty of Fisheries, Universitas PGRI Palembang. which can cause color in water, water temperature, oxygen content, and salt content. In the aquatic environment, natural food is also available for the growth and survival of fish, namely silk worms, Daphnia sp and mosquito larvae. The combination of these two factors will support fish farming in ponds so that it can run well. This study focuses on analyzing the characteristics of water quality and the presence of natural feed in the pond environment to support fish farming. The results showed that the water quality parameters were good enough to support fish cultivation, besides the presence of natural food and the development of life in the pond was quite good in accordance with the existing water quality conditions. Although natural food has no significant effect in supporting the development of fish weight and length, it becomes a stimulus to increase fish appetite so that it can develop normally[10].

Journal with the title Feeding Management on Enlargement of Tilapia (Oreochromis niloticus) made by Rezkyana Amalia, Amrullah, and Suriati from the State Agricultural Polytechnic of Pangkajene Islands which contains about one of the factors that influence the growth of cultivated fish is feed. Feed is the biggest cost in raising fish, usually around 60-75% of the total production cost. Based on this, this activity aims to determine the effect of feeding management on tilapia rearing in concrete ponds. The method of implementation is to observe the growth of tilapia during the maintenance period, survival (Survival Rate SR) and water quality parameters. The results obtained are by performing feeding management on rearing tilapia, it will produce a biomass of 504 kg with an average weight of 180 g/head and a fish survival rate of 93.2%. This shows that the application of feeding management supported by optimal water quality parameters will result in a high level of fish survival[11].

Journal with the title Analysis of Survival and Growth of Pandu Saline Tilapia (Oreochromis niloticus) Seeds Raised in Tugu Ponds, Semarang with Different Densities was made by Ahmad Sarpawi Ibrahim Nasution, Fajar Basuki, Sri Hastuti. This journal contains about growth will be hampered because the energy that should be used for growth is used by fish to defend themselves from environmental pressures. The aim of the study was to determine the effect of different densities on the growth of Pandu tilapia (O. niloticus) fry and also to determine the best density for survival (SR) and growth of Pandu tilapia (O. niloticus) seeds reared in ponds. This research was carried out for 40 days of observation, starting from April to May 2013 in Tambak village, Tugu sub-district, Semarang. The test fish used were Pandu tilapia (O. niloticus) sized 3 - 5 cm (D20-D60) with a weight of 0.58 g. The method used in this study is a field experiment method using a completely randomized design (CRD) pattern with 3 treatments and ± 3 replications each. The differences in stocking density in each treatment A, B, and C were 15 or 9 fish/m2, 25 or 15 fish/m2, and 35 or 21 fish/m2 reared in ponds using hapa. Fish were fed 5% of the weight of fish biomass in the morning, afternoon, evening at 08.00, 12.00, and 16.00 WIB. The variables tested were specific growth rate (SGR), survival rate (SR), feed conversion production rate (FCR) and water quality. The results showed that the stocking density was not significantly different (P0.01) in growth, production rate, and feed conversion ratio. The specific growth rate values for each treatment A, B, and C were (6.94±0.028%), (6.23±0.041%), and (5.63±0.003%). The survival values for each treatment A, B, and C were (97.78±3.85%), (97.33±2.31%), and (97.14±2.86%). The production level values for each treatment A, B, and C were (99.96±7.14 g), (178.98±10.96 g), (257.56±16.67 g) FCR values for each treatment A, B, and C were (0.58±0.04), (0.75±0.04), and (0.89±0.06). The results of the measurement of water quality parameters for temperatures ranged from 26 ± 310C, Salinity 12 ± 14 ppt; pH 7.97 ± 8.69; DO 3.25 ± 3.78 mg/l; and ammonia 0.02 ± 0.04 mg/l. Based on the results of the study, it can be concluded that the best survival and growth rates are at a density of 15 or 9 birds/m2[12].

Journal entitled Performance of Water Quality, Growth, and Survival of Tilapia (Oreochromis niloticus) in Aquaponic Systems with Different Types of Plants made by Bella Manik Hapsari, Johannes Hutabarat*), Dicky Harwanto from the Faculty of Fisheries and Marine Sciences, Diponegoro University contains regarding the management of aquaculture waste can be done through the application of a recirculation system with a biological filter in the form of plants/called an aquaponics system. The purpose of this study was to determine the effect of using different types of plants and the most effective types of plants in this study to maintain the performance of water quality, growth, and survival of tilapia. The test fish used had an initial length of 9-11 cm and an average initial weight of 15.56±0.34 grams totaling 360 fish for 12 rearing containers. This study used an experimental method with a completely randomized design (CRD), with 4 treatments and 3 replications. The treatments used were without an aquaponic system (A), aquaponics system using pakchoi plants (B), aquaponics system using water spinach plants (C), aquaponics system using caisim plants (D). The data collected included fish water quality, relative growth rate/RGR of fish, feed conversion ratio/FCR of fish, plant growth, and survival/SR of fish. The results showed that the water quality, RGR, FCR, and SR of tilapia treated by aquaponics system using water spinach (C) reached the highest value, namely ammonia VTR 94.97±6.21; 101.46±11.78; 107.36±12.05 g/m3/day, RGR 1.23±0.05%/day, FCR 1.63±0.09, and SR 83.33±3.34%[13].

The journal with the title Growth and Survival Rate of Tilapia (Oreochromis. Sp) Red Strain and Black Strain Maintained in Salinity Media created by M. Yusuf Arifin contains about this study aims to test the growth and survival of red-line tilapia (Oreochromis. SP) and black lines reared in Tanjung Jabung Regency on the West media embankment in water salinity. The results of this study are expected that one of the tilapia strains can function as a substitute for shrimp farming which is considered unfit to be kept a farm in the area. This research was conducted from September to December 2015 which took place in the village of Dualap River, Tanjung Jabung Regency, West Jambi. The test fish of the tilapia strain used is red and black lines were obtained from the Jambi Freshwater Cultivation Center (BBAT) with a weighted average as much as 8 grams / head. Parameters observed were growth rate and survival rate. The data obtained were analyzed statistics using t-Test. The maintenance of the test fish was carried out for 60 days with sampling time i.e. days 0, 30, 60, and 90 days[14].

The journal with the title Growth Rate and Feed Efficiency of Tilapia (Oreochromis niloticus) Reared in Plastic Lined Pond with Starved Periodically created by intan Permatasari, Yulisman and Muslim contains about Starved was one effort that can reduce the feed consumption and feed residues without decreasing growth of cultured fish. The purpose of this research was to determine the effect of starved periodically to the specific growth rate and feed efficiency of tilapia reared in the pond. The research had been conducted in Laboratorium Budidaya Perairan, Faculty of Agriculture, Sriwijaya Unversity on April – Juni 2016. This research method used Completely Randomized Design with four treatments and three replications that was every day feed without starvation (P0), one day feed one day starvation (P1), two days feed one day starvation (P2) and three days feed one day starvation (P3). Parameters of this research are specific growth rate, feed efficiency, survival rate and water quality (temperature, pH, DO, ammonia). The result showed that starved periodically significantly effect to the growth rate and feed efficiency of cultured tilapia in the pond. Treatment P1 (one day feed one day starvation) gave highest specific weight growth rate and specific length growth rate which were 2.32%.day-1 and 1.27%.day-1 then feed efficiency was 84.46%. The highest survival rate occurred in treatment P1 (one day feed one day starvation) 82%. Water quality of this research were temperature 27.0-31.5 oC, pH 6.8-7.9, dissolved oxygen 4.53-7.23 mg.L-1 , and ammonia 0.01-0.30 mg.L-1 [15].

3. METHOD

In this Final Project, the outline of the Final Project flow can be seen in the Figure and the explanation is as follows :

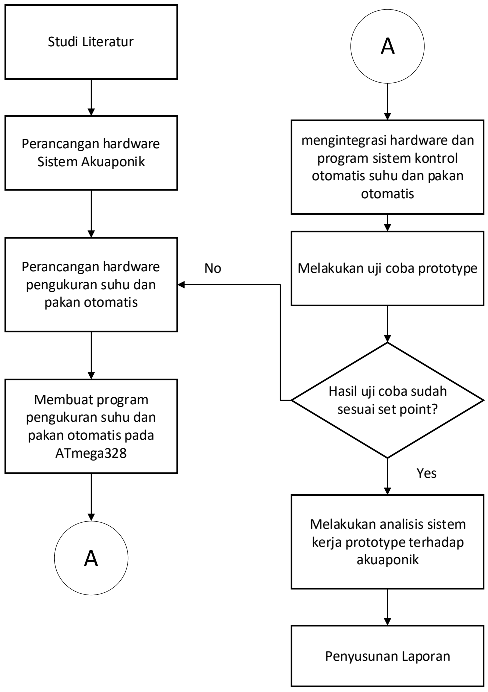

Figure 3. 1 System Flowchart

3.1. Studi Literature
The above system model is a literature study to understand the basics of aquaponics and the components used. The studies used are in the form of journals and papers about aquaponics, temperature measurement systems, and automatic temperature control systems and automatic feeding.

3.2. Aquaponics Hardware design
The aquaponics system is assembled in the form of fish ponds, pipes where plants are planted, water pumps and planting media. After the assembly is complete, the fish will be released into the pond and the plants will begin to be planted in the pipe that has been given the planting medium. The installed water pump will flow water into the pipes that have been planted with plants.

3.3. Automated Feeding and Temperature Measurement Hardware Design
Hardware assembly of temperature measurement tools and automatic feed of aquaponic fish pond water is sensed by the DS18B20 temperature sensor. The sensor is connected to the ATmega328 to process sensor measurement data into a control system. Media temperature control is carried out by peltier and heater. Peltier as a water cooling module and heater as a water heater. Meanwhile, the automatic feed system uses a servo motor as a valve for opening and closing the fish feed container to dispense feed into the fish pond.

3.4. Creating an Automatic Temperature Measurement and Feed System Program on the ATmega328
After the measurement system is complete, the control system can be started. The control system is made using the ATmega328 . microcontroller.

3.5. Integrating Hardware and Programs Automatic Temperature and Feed Control System
Making control system hardware using ATmega328 to adjust the input input to the relay so that the heater and peltier can turn on alternately according to the incoming sensing input. Integrate real time system of RTC to control feeding by servo motor.

3.6. Prototype Test
After the circuit has been completed, the test can be carried out to get the results of sensing and controlling the tool. The object being tested is a temperature sensor that senses the temperature of the aquaponic pond water. In addition, testing and ensuring that the control system that is set on the ATmega328 is working properly. Ensure and test the peltier and heater as an automatic temperature control tool that functions properly and test the angle of the servo motor and the programmed time set is running well.

3.7. Trial Results Are in Accordance with the Set Point?

If the tool that has been tested is functioning properly, the analysis will continue until the time of determination is 30 days. If the tool being tested has not been able to work properly, then the tool will be reconfigured.

At a temperature of 28°C, the automatic control system will activate the heater to warm the pool. When the temperature is at 32°C, the automatic control system will activate the Peltier to cool the fish pond water. Test the servo motor opening angle to determine proper feed valve opening. In addition, testing and determining the valve opening delay time so as to produce feed results that match the desired amount of feed.

3.8. Performing Prototype Work System Analysis on Aquaponics

The analysis carried out is to collect data on the parameters of kale and tilapia and analyze the prototype work system has been able to work well or not. The results of the data will be collected as a result of the analysis of this final project.

3.9. Preparation of Reports

The preparation of the report will be carried out if the prototype has achieved the results of the analysis within a period of 2 weeks. The results of the analysis are the results of sensing sensors, control systems, and observations of the growth of objects (tilapia and kale).

4. RESULT AND DISCUSSION

4.1. Aquaponics Design

The Aquaponic design that has been made is shown in picture 4.1 with a height of 1.2 m . for aquaponics paralon.

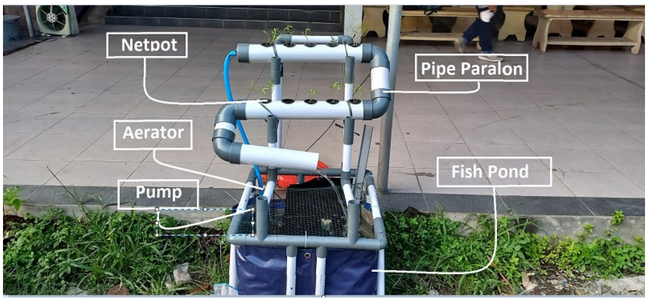

Figure 4. 1 Aquaponics

The realization of the aquaponic design that has been made and has a pool size of 50cm x 50cm x 50cm with a water height of 30 cm. The net pot used is 10 pots.

The electrical equipment for the automatic temperature and feed control system that is assembled can be seen in picture 4.2.

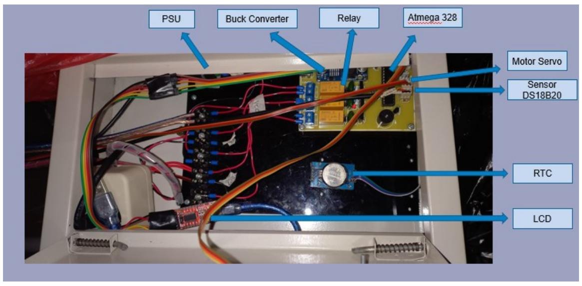

Figure 4. 2 Electrical

The electrical design is designed using ic atmega328 as a microcontroller and uses 3 relays where the relay is used as a switch to activate temperature control and automatic feed in tilapia ponds. 1 relay is used to activate the heater when the temperature is below 28°C and 1 relay is used to activate the peltier when the temperature is above 32°C. then the last relay is used to activate the pump to pump ammonia antibiotic liquid into the tilapia pond in aquaponics.

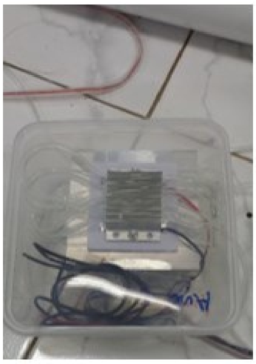

Figure 4. 3 Electrical and Peltier

Peltier functioned as a pond water cooler in aquaponics using a small hose media that was fed with water using a water pump that was running continuously.

4.2. Temperature Sensor Validation

Validation was carried out using a mercury thermometer validator and DS18B20 temperature sensor which was carried out on June 6, 2022. The data taken has a span of 5 minutes for each data collection in aquaponic ponds. The control test being tested is the temperature control test that has been applied. To carry out the control test, the test was carried out for 3 days, namely in the morning, afternoon and evening. Data is taken directly from the aquaponics system by placing the temperature sensor into the pond and monitoring the results of the sensing sensor on the screen. Monitoring the temperature value is also accompanied by monitoring the control system, namely whether or not the heater and Peltier are on according to the set points that have been set. Based on Table 4.2 data, when the temperature is below 28°C, the heater will turn on and when the temperature is above 32°C, the Peltier will turn on.

The following is the table data validation of the temperature sensor that has been done:

Table 4. 1 Data Validation of Temperature Sensor

time	DS18B20	validator	Correction	error	Accuracy (%)
09:05	26.12	27.00	0.88	3.26	96.74
09:10	26.30	27.00	0.70	2.59	97.41
09:15	26.44	27.00	0.56	2.07	97.93
09:20	26.50	27.00	0.50	1.85	98.15
09:25	26.50	27.00	0.50	1.85	98.15
09:30	26.56	27.00	0.44	1.63	98.37
14:05	27.94	28.50	0.56	1.96	98.04
14:10	27.94	28.50	0.56	1.96	98.04
14:15	27.87	28.50	0.63	2.21	97.79
14:20	27.94	28.50	0.56	1.96	98.04
14:25	28.00	28.50	0.50	1.75	98.25
14:30	28.00	28.50	0.50	1.75	98.25
21:05	27.50	28.00	0.50	1.79	98.21
21:10	27.56	28.00	0.44	1.57	98.43
21:15	27.56	28.00	0.44	1.57	98.43
21:20	27.50	28.00	0.50	1.79	98.21
21:25	27.62	28.00	0.38	1.36	98.64
21:30	27.62	28.00	0.38	1.36	98.64

With a graph of the data as follows:

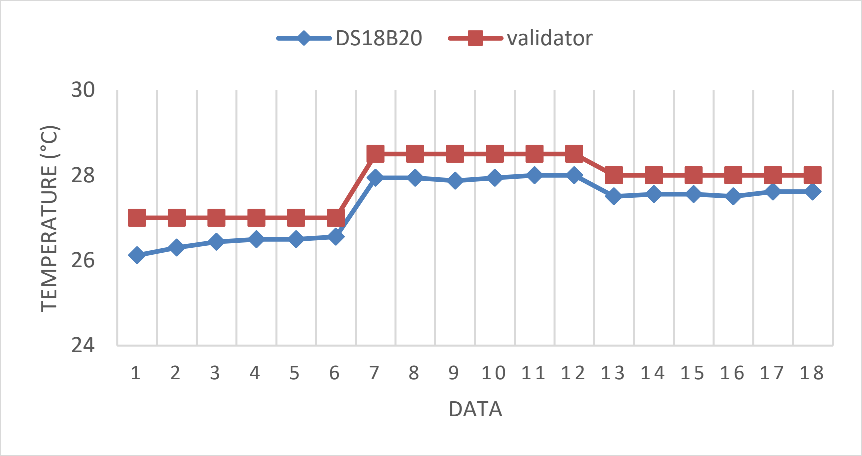

Figure 4. 4 Graph Validation of Temperature Sensor DS18B20

In the graph it can be seen that the sensor and validator readings do not have a wide reading range. This is evidenced by the average reading error value obtained is 1.91 with an average accuracy value of 98.09%. With this accuracy value, it can be stated that the sensor readings are quite accurate.

4.3. Control Test

Temperature control testing was carried out using 3 samples using 3 different containers. From the three containers, the speed of temperature changes varies depending on the amount of water. The first container is to use a gallon with a water volume of 1.76625 L with an initial water temperature of 28.37 °C. testing with this gallon container takes 3 hours for the Peltier test and 30 minutes for the heater test. The graph of the temperature response in the gallon container can be seen in picture 4.5.

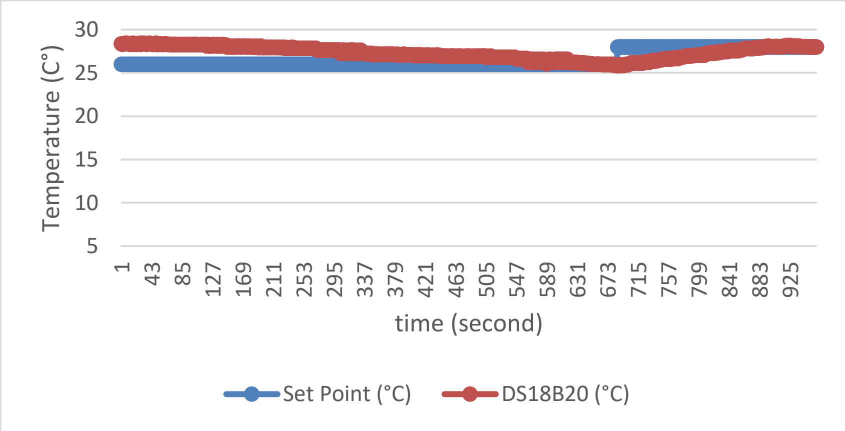

Figure 4. 5 Control System Respone Graph on Container 01

The second test was carried out on a lunch box with a size of 16 cm x 16 cm x 7 cm. The volume of water used in this container is 0.6631 L with an initial temperature of 31.56 °C. the second test takes as much as 1 hour 30 minutes for the Peltier test and it takes 40 minutes for the heater test. The graph of the temperature control test in the second container can be seen in picture 4.6.

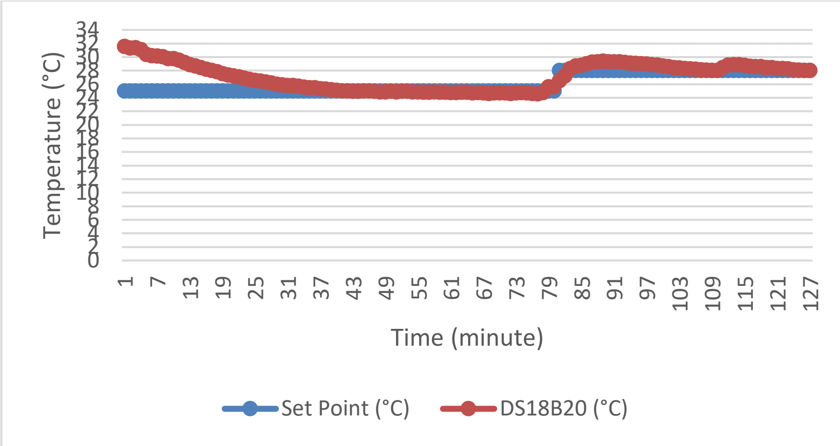

Figure 4. 6 Control System Respone Graph on Container 02

The third test was carried out on a 1.5 L drinking water bottle with the volume of water used was 0.3285 L. The initial temperature of the water before the test was 27.12 °C. testing on the current container is carried out for 20 minutes for the Peltier test and 45 minutes for the heater test. The graph of the temperature control response in the third container can be seen in picture 4.7.

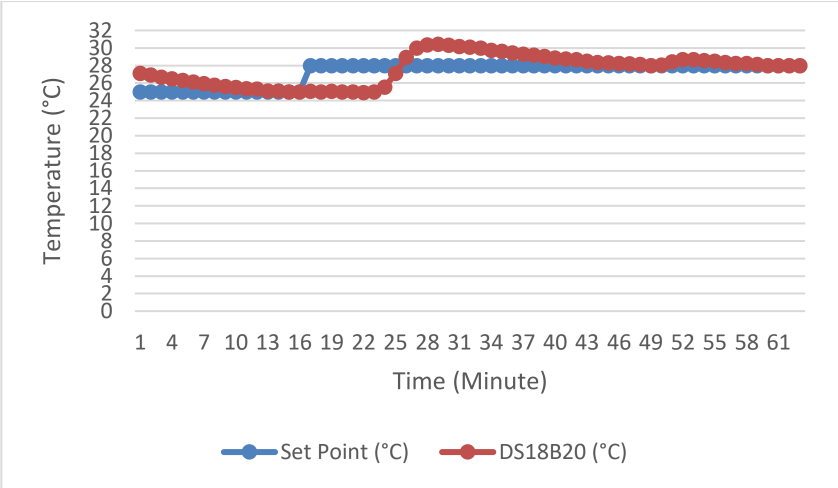

Figure 4. 7 Control System Respone Graph on Container 03

Based on the testing on the 3 samples, it can be said that the control system that has been made can work well. System testing depends on the amount of water. The more water used, the longer the cooling and heating process. The cooling process is slower because the equipment used does not match the amount of water used in aquaponics. Cooling can be done quickly with less water as shown in the third container.

4.4. Feeding Tilapia

Feeding of tilapia is based on the weight of the fish and also the time of feeding. Fish feed is given 3 times a day with feeding times at 08.00, 12.00, and 17.00 WIB on an ad satiation basis by the National Standardization Agency, 1999.

Table 4. 2 Fish Feed Adjustment Table

Average fish weight (g)	Age (days)	week	Servo Angle (°)	Delay (ms)	Feed Weight (g)
5	80	1	118	1400	7.5
7	100	1	122	1400	10.5
9	100	2	123	1300	13.5
11	100	2	124	1400	16.5

Fish weight affects the feeding of fish based on the servo motor angle that is set. In addition, the opening of

the servo motor valve is also set to a time setting in the form of a delay to obtain the appropriate weight of feed that the fish need. In the first week, in one feeding, 7.5 grams were given to fish with an average weight of 5 grams with an angle of 118° and an opening delay of 1400 ms.
The feeding of fish is also based on the age of the fish in Table 4.3 where the reference of that age is from the SNI document for tilapia rearing made by BSN (National Standardization Agency) in 2009 which is shown in Table 4.4.

Table 4. 3 Quantitative Criteria for Tilapia Seed Class Seed Spread

No.	Criteria	Unit	Larva	Seed			
				PI		PII	PIII
1	Age	day	10	30	40	80	100
2	Total length	Cm	0,9 - 1,3	1 - 3	3 - 5	5 - 8	8 - 12
3	Min weight	Gram	0,002	0,5	2,5	4,5	2,5
4	Size uniformity, min.	%	90	90	90	80	80
5	Color uniformity, min	%	90	90	90	95	95

4.5. Comparison of Kangkung Plant Growth Before and After the Control System
The growth data of plants and fish were compared before and after the control and automatic feed were installed. The data is compared to find out which plant and fish growth is the best between before and after the automatic temperature control and feed system is installed.

4.5.1 Plant Growth Rate Data
To determine that the kangkung plants that are kept grow well, it is necessary to measure and analyze the growth of these plants and fish. Measurement and data analysis of the growth rate of kale before the installation of the control system that has been carried out can be seen in Table 4.3.

Table 4. 4 Plant Growth Before Installed Control System

week	Plant height (cm)	Absolute Length	Growth rate (%)
1	2.40	3.2	22.9
2	5.60		

In the table and also the picture graph shown above, it is known that the kale plant grows at a growth rate of 22.9% with an absolute plant length of 3.2 cm.
The table data for plant growth rates after installing the control system is shown in Table 4.4.

Table 4. 5 Plant Growth After Installed Control System

week	Plant Height (cm)	Absolute Length	Growth rate (%)
1	2.52	4.7	33.71
2	7.24		

The table shows the growth rate of kale which was higher than before the control system was installed, which was 33.71%. In addition, the planted kale plant has an absolute length of 4.7 cm.
If the two tables were compared, starting from plant height, plant weight, absolute length and also plant growth rate, the values obtained showed higher values after the control system was installed.
The Picture comparison chart between Table 4.5 and 4.6 is as follows :

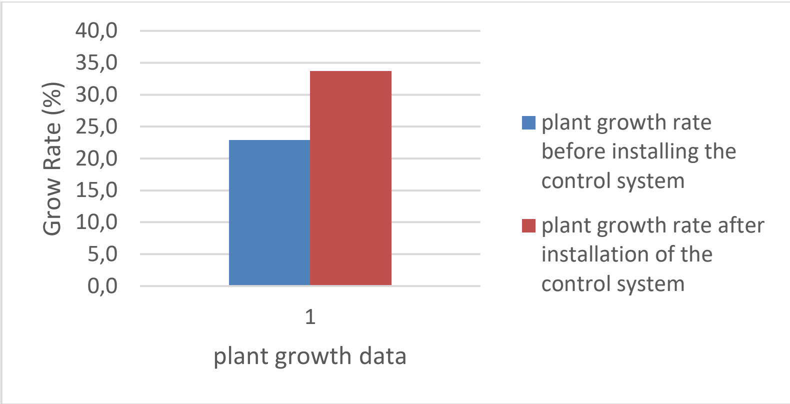

Figure 4. 8 Comparison Chart of Plant Growth Before and After the Control System was Installed

4.5.2 Fish Growth Rate Comparison Data

The growth of fish before being given a control system in Table 4.6 which includes the growth rate of fish and the survival rate observed in 4 weeks. In the table, it is known that the growth rate of fish is not high enough and the survival rate value can be said to be quite high, especially when the system is running well as in the 2nd week which shows a survival rate of 82%. The survival rate value from week 1 to week 2 is getting higher as evidenced by the average (RGR) Relative Grow Rate of the highest fish in the 2nd week of 7.14% and the number of fish which is slowly not decreasing with a survival rate of 82%.

Table 4. 6 Fish Growth Table Before Installation of Control System

week	initial average weight (gr)	final average weight (gr)	initial number of fish	final fish count	RGR (Relative Grow Rate) (%)	FCR (Feed Conversion Ratio) (g)	survival rate/week (%)
1	6	8.6	51	34	7.14	12.50	67
2	8.6	12	34	28			82

The table of fish growth after the control system is installed is shown in Table 4.8.

Table 4. 7 Fish Growth Table After Installed Control System

week	initial average weight (gr)	final average weight (gr)	initial number of fish	final fish count	RGR (Relative Grow Rate) (%)	FCR (Feed Conversion Ratio) (g)	survival rate/week (%)
1	3	3.9	40	40	11.2	21.07	100
2	3.9	7.7	40	40			100

Table 4.7 shows that the growth rate of fish is higher than before the control system was installed. This is evidenced by the RGR value of 11.2% and the FCR value of 21.07%. In addition, no fish died as evidenced by the survival rate value which showed a value of 100%.

The picture graph of the comparison of the survival rate of tilapia before and after the control system is installed is shown in picture 4.7.

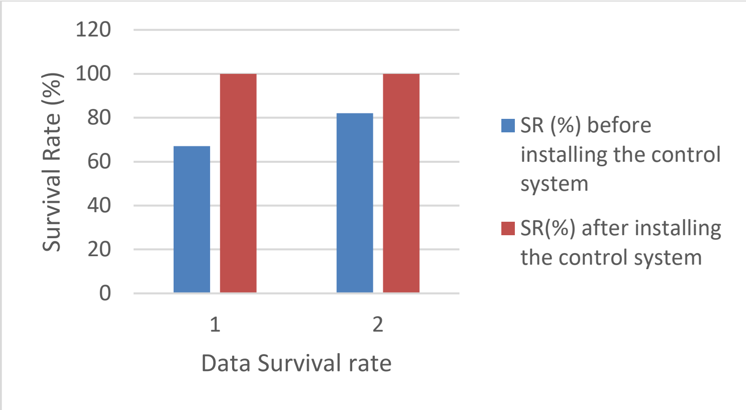

Figure 4. 9 Fish Survival Rate Comparison Chart Before and After the Control System was Installed

The picture graphic shown in picture 4.9 has a far comparison because the survival rate of fish in the treatment after the control system was installed was 100% compared to the treatment before the control system was installed which only had a survival rate of 82%.

5. CONCLUSION

The accuracy of the DS18B20 temperature sensor reaches a value of 98.09% with an average reading error of 1.91. This indicates that the sensor is accurate enough to be used in the system. The temperature control device that has been made can function properly, as evidenced by the stable temperature sensing results. The stable temperature sensing results also make the actuator work according to the specified set point. The cooling device/peltier used is too small for a 0.5m x 0.5m x 0.5m pool so that the cold temperature produced by the peltier is not strong enough to cool the pool water when the temperature is above the highest setpoint. Peltier is only able to cool in smaller containers for faster cooling results. The automatic feed that has been made has been able to function properly as evidenced by the amount of feed that has been issued in accordance with the angle setting and the specified time delay.

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