Home Scale Yogurt Incubator Control System using Microcontroller ATmega328

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Abstract. The process of producing yogurt has been known since long time ago, but usually it carried out traditionally without using control technology. This paper aims to produce easy use of home-scale yogurt incubator system using Microcontroller ATmega328. The incubator was modified from two-liter volume of rice cooker controlled by ATmega328, where the temperature is measured by the DS18B20 temperature sensor. ATmega 328P also acts as a time-controller during the process of producing yogurt. The yogurt incubator system resulted in this research works well according to the system designed, including pasteurization, cooling inoculation, and incubation processes. The system can work automatically and very easy to use. Compare with conventional system, this system even works faster and able to produce better quality yogurt.

1. Introduction
Many scientists have confirmed the importance of dairy products because milk contains essential nutrients for body health [1]. One of the products that can be processed from milk is yogurt. The process of making yogurt utilizes the bacteria Streptococcus thermophilus and Lactobacillus bulgaricus [2] which can improve the balance of human intestine [1]. The fermentation process in yogurt should be controlled to produce good quality yogurt [3]. The process of producing yogurt in incubator including pasteurization, inoculation cooling, and incubation processes [4]. The incubator is a temperature controlled heater [5].

The incubator used in the process of producing yogurt has been widely available in the market and the price is quite affordable [6]. But the incubator has a disadvantages, such as not automatic as well as requires a long time of about 8-10 hours. Meanwhile, in the market has also available automatic incubator, however the price is quite expensive.

From the existing problems, in this paper, we propose the system of yogurt incubator by modifying the rice cooker and based on microcontroller ATmega328. The advantages of the system developed are works automatically and low price as well as easy to use. By using a used rice cooker for the incubator it can help government program for reducing electronic waste, which increase in line with technology developments.
2. Methods

2.1. Research design
The design process of this tool through several stages, shown in Figure 1 flowchart follows:

![Figure 1. Research design flowchart.](image)

2.1.1. Literature study. At this stage is done the collection of theory and information about the final project. Theories and information obtained are drawn from various sources such as books, journals, and scientific articles on the internet. Theories and information collected learn about yogurt, ATmega328 microcontroller, DS18B20 sensor, and others related to the final project.

2.1.2. Work system design. Designing work system tools from start to end process.

2.1.3. Determining of basic design tool. Determining the desired design and collecting materials and tools to be used.

2.1.4. Component testing. Checking the components used to run well or not, so when the process of assembling the tool running smoothly.

2.1.5. Tool design. Make tools with tools and materials that have been prepared.
2.1.6. **Designing software.** The final stage of the research by photographing or video of the tool has been successful.

2.1.7. **Tools testing and analysis.** Testing after the tool has been completed. To see if the tool created is successful or not.

2.1.8. **Documentation.** The final stage of the research by photographing or video of the tool has been successful.

2.2. **Design system**
The design of this incubator is controlled by ATmega328 which is connected to the DS20B18 temperature sensor. The temperature sensor will measure the temperature during the yogurt making process. The temperature and timing results will be displayed on the LCD. This tool is focused on the temperature sensor because all components work according to a predetermined temperature.

Block diagram design system can be described in the figure 2.

![Block diagram design system](image)

**Figure 2.** Block diagram design system.

2.2.1. **Temperature sensor DS18B20.** DS18B20 is a 1-Wire digital temperature sensor from IC Maxim. Display degrees in Celsius with precision 9 to 12 bits, from -55 to 125 (+/- 0.5). This temperature sensor has 3 feet that are, ground, data, and Vcc. In this design serves to measure the temperature of the milk. Serves as a measurement of milk temperature during the process of making yogurt.

2.2.2. **Microcontroller ATmega328.** Microcontroller ATmega328 is an AVR 8 bit microcontroller output. ATmega328 has 3 main PORT that is PORTB, PORTC, and PORTD with total input/output pin of 23 feet. This microcontroller output from Atmel having RISC architecture (Reduce Instruction Set Computer). It has a 14 pin digital I/O pin of which is PWM (Pulse Width Modulation). In this design, the microcontroller serves as the control that governs all movement of the tool [6].

2.2.3. **LCD.** LCD (Liquid Crystal Display) is one of the important display techniques to use for applications [7]. Usually to display information as well as an image. Here serves to display the amount of temperature and the length of time the process of making yogurt.

2.2.4. **Motor.** In theory, a DC motor is an electric motor that requires a direct current voltage supply or DC current (Direct Current) on the field coil to be converted into mechanical energy. The field coil on
the motor is called the stator, and the anchor coil is called the rotor. In this design, it is evacuated to move the stirrer.

2.2.5. **LED.** LED (Light Emitting Diode) is an electronic component that can emit monochromatic light when given the forward voltage made of semiconductor material. LEDs perform less power and have more efficient power [8]. LEDs have a variety of colors and their appearance can be changed in the form of flip-flops. In this design LED functions as a sign of the system has been active.

2.2.6. **Pump 1.** The pump is a machine to drive fluid. The pump moves the fluid from the low pressure to the higher pressure place, to overcome this pressure difference, energy is required. In this design to drain the bacteria needed in making yogurt.

2.2.7. **Pump 2.** The pump is a machine to drive fluid. The pump moves the fluid from the low pressure to the higher pressure place, to overcome this pressure difference it takes energy. In this design to drain the anti-yeast needed in the manufacture of yogurt.

2.2.8. **Blower.** A blower is a machine or apparatus used to raise or enlarge the air or gas pressure to be drained in a particular chamber as well as the suction or vacuum of air or certain gases. Helps speed up the process of cooling milk before it is given bacteria.

Work system of incubator can be described in the figure 3.

![Figure 3. Work system flowchart.](image-url)
This incubator work system starts from pasteurization process for ± 30 minutes reaching 80 °C, by activating heater and motor. Then cooling the temperature inoculation ± 25 minutes to reach 45 °C temperature that activates the blower and motor. After the temperature has reached 45 °C given the seeds of bacteria and anti-yeast flowed by pumps 1 and 2 assisted stirring briefly by the motor. Last incubation process takes 8-10 hours with temperature below 45 °C and above 25 °C.

### 2.3. Designing software (program)

Software used in the design of this tool is Arduino IDE. Programming using C++ language. Program from software uploaded to ATmega328 via Arduino. The data goes into the microcontroller IC which will be the system's work regulator of the tool [9]. Designing software can be described in the figure 4.

![Figure 4. Arduino IDE program.](image)

Arduino IDE consists of 3 parts:
- Editor
- Compiler
- Uploader

### 3. Results and discussion

From the design of the yogurt incubator and the test results of the tool works well and in accordance with the work system that has been designed. The process of this tool through 3 stages of the process of pasteurization, cooling inoculation, and incubation. Calculation of time and temperature can be told in table 1:

| Process              | 1 Liter | 2 Liter |
|----------------------|---------|---------|
|                      | Temp    | Time (s) | Temp    | Time (s) |
| **Pasteurization**   | 80 °C   | 907     | 80 °C   | 1478     |
| **Cooling Inoculation** | 45 °C   | 753     | 45 °C   | 1400     |
| **Incubation**       | 25 °C < 45 °C | 28800   | 25 °C < 45 °C | 28800   |

In the above table shows the results of comparative analysis of the time of manufacture of yogurt 1 liter and 2 liters. It can be seen that the less milk volume is used, the more rapid the time. First, there is
the pasteurization process, the process by which the initial temperature of milk is 26.87 °C for the 1 liter and 28.25 °C for which 2 liters is heated using a heater to a temperature of 80 °C. In this process takes 907 seconds and 1478 seconds. Comparison of temperature rise of milk in process of making yogurt 1 liter and 2 liters can be seen in figure 5 and 6:

**Figure 5.** Temperature rise in 1L volume.

A temperature rise of 1 liter of milk from 30 °C to 80 °C takes 907 seconds.

**Figure 6.** Temperature rise in 2L volume.

A temperature rise of 2 liter of milk from 30 °C to 80 °C takes 1478 seconds.

Second, there is an inoculation cooling process that is, the temperature drop from 80 °C to 45 °C to put bacterial seeds and anti-yeast. At this temperature reduction process takes 753 seconds and 1400 seconds. Comparison of temperature rise of milk in process of making yogurt 1 liter and 2 liters can be seen in figure 7 and 8:
Figure 7. Decrease in temperature in 1L volume.
A decrease in temperature of 1 liter of milk from 80 °C to 45 °C takes 587 second.

Figure 8. Decrease in temperature in 2L volume.
A decrease in temperature of 2 liter of milk from 80 °C to 45 °C takes 1400 second.

The third is an incubation process in which the milk that has been given bacteria and seeds is silenced for 8 hours with temperatures below 45 °C and above 25 °C. After all the process is done yogurt. Yogurt results can be seen from the following figure 9:

Figure 9. Yogurt results.

This incubator has a deficiency in the pasteurization process, especially as the volume of milk increases. The greater the volume, the longer the pasteurization process. The heating of milk during the
pasteurization process with incubators or manually is almost the same time. The time required in the process of making yogurt manually about 30 minutes. In this experiment as much as 2L takes ± 25 minutes, if the volume increases again then the time can be increased again or beyond the time of making yogurt manually. The heater settings follow the working system of the rice cooker, so the heat increase cannot be controlled. The process will be even better if the heater can be controlled so the results of the process become faster.

4. Conclusions
The yogurt incubator system resulted in this research works well according to the system designed, including pasteurization, cooling inoculation, and incubation processes. The system can work automatically and very easy to use. Compare with conventional system, this system even works faster and able to produce better quality yogurt. The system still has the disadvantage, especially during the pasteurization process. The heat should be controlled so that the warming of milk can be faster.

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