Vol. 13, No. 1 (2024): 250 - 259 http://dx.doi.org/10.23960/jtep-l.v13i1.250-259

JURNAL TEKNIK PERTANIAN LAMPUNG

ISSN 2302-559X (print) / 2549-0818 (online)
Journal homepage : https://jurnal.fp.unila.ac.id/index.php/JTP

Design and Examination of Yogurt Maker Machine with Sensor Temperature DS18B20

Dewi Yunita[1,✉], Alfi Syahri Nurazis[1], Juanda Juanda[1], Indera Sakti Nasution[1], Satriana Satriana[1]

[1] Department of Agricultural Product Technology, Faculty of Agriculture, Syiah Kuala University, INDONESIA.

Article History:

Received : 27 July 2023
Revised : 29 August 2023
Accepted : 20 September 2023

Keywords:

DS18B20,
Temperature,
Yogurt maker machine,
Sensors

Corresponding Author:
✉ dewi_yunita@usk.ac.id
(Dewi Yunita)

ABSTRACT

Many commercial yogurt brands do not have a minimum total lactic acid bacteria count (10^7 CFU/g) due to long distribution with inappropriate storage condition. This leads local producers to produce yogurt. However, commercial yogurt maker machines commonly have a low capacity of 0.5 to 2 L. This study aims to design a yogurt maker machine with a capacity of 15 L with a temperature setting of 37 – 45 °C. The design and flow system were conducted by arranging the electronic components consisting of 5V 4 channel relay, ESP32 module, DS18B20 temperature sensor, RTC, 12V fan (along with 12 VDC connecting components), 220V heater, 20×4 LCD and plugs (adapter) 220 VAC cable. The yogurt maker machine was evaluated for accuracy of temperature readings (DS18B20 sensor and thermometer), response to incubation time and plain yogurt making. The T-Test was used to compare the differences between the two types of sensors measuring instruments. The results showed that the accuracy of temperature readings using the DS18B20 sensor was better than a thermometer, with a distance scale of 0.35-0.75 °C (P-value ≤ 0.05). Temperature testing using milk can be carried out with a temperature range of 37-45 °C for 12 h.

1. INTRODUCTION

Yogurt is the oldest milk processing and preservation product in the world using the fermentation method. According to SNI 2981:2009 (BSN, 2009), the definition of yogurt is a product made from fermented milk or milk dissolved using *Lactobacillus bulgaricus* and *Streptococcus thermophilus* bacteria or other suitable *lactic acid bacteria*, with or without other food ingredients and permitted food additives. Yogurt has a semi-solid consistency resembling pudding (Utami *et al*., 2020). Yogurt has many benefits that make it popular and favored by consumers. According to Tamine & Robinson (2007), yogurt contains several nutrients that are lacking in some types of food such as calcium, vitamin D, and potassium. Yogurt can also improve bone strength, maintain weight, promote heart health, support metabolism, as well as digestive health and immune system (Sarah *et al*., 2021). The vitamin content in yogurt such as vitamin A, B3, B12 can help maintain facial skin from premature aging, and consuming yogurt can be an alternative diet for weight loss (Maharani & Ayuningtyas, 2018).

The *lactic acid bacteria* (LAB) commonly added as starter cultures in yogurt production are *Streptococcus thermophilus* and *Lactobacillus bulgaricus*. The principle of making yogurt is the fermentation process of the sugar component in milk, namely lactose, into lactic acid and other acids (Hasanah & Rosma, 2021). The lactose contained in milk will be broken down into glucose and galactose by lactic acid bacteria so this will make it easier to be digested and absorbed by the human digestive system (Mustika & Yasni, 2019). According to Layadi *et al*. (2009), the starter cultures in yogurt must reach a sufficiently high amount (more than 10^7 CFU/ml) so that they can act as probiotics when consumed. Probiotics are live microorganisms that provide health benefits to their host when consumed in adequate amounts. Probiotics must also be able to survive in the digestive tract (Sari *et al*., 2019).

In the yogurt-making process, temperature plays a crucial role in regulating the growth of the LAB used. The appropriate temperature can influence the fermentation rate, bacterial growth, and the final characteristics of yogurt. The commonly used ideal temperature in yogurt production is around 40-45 ℃ (Layadi *et al*., 2009). The optimum temperature for *Streptococcus thermophilus* is around 42℃, while for *Lactobacillus bulgaricus*, it is 45 ℃ (Purwandaru *et al*., 2021). Maintaining a stable temperature throughout the fermentation process is crucial in yogurt making. Large temperature variations can affect bacterial growth, potentially leading to products with deviating characteristics (Amar *et al*., 2018). However, the total LAB requirements by the CODEX standard (CAC, 2003), which is a minimum of 10^7 CFU/g, generally are not met in commercial yogurts marketed around the city of Banda Aceh. It is suspected that long distribution processes with inadequate storage conditions are one of the causes. Additionally, some yogurt productions do not use suitable equipment and are unable to maintain temperature stability during yogurt incubation. Therefore, local yogurt producers should have proper yogurt maker machines to ensure constant temperature control.

Commercial yogurt maker machines generally have capacities ranging from 0.5 to 2 L with prices starting from Rp 150,000 to Rp1,000,000. The working principle of a yogurt maker machine is similar to a rice/food warmer, which maintains the temperature according to the set/adjusted settings (Sumarmono, 2016). There are two types of available yogurt maker machines: one with a single fermentation container (for making stirred yogurt), and the other with several (2-8) fermentation containers (for making set yogurt) (Gunawan & Sukardi, 2020). Several studies on yogurt-making devices have been conducted despite having some drawbacks and limitations. Amat *et al*. (2018) designed a household-scale yogurt maker with a stainless-steel incubator with a size of $20x25x35cm^3$. The device has a maximum capacity of 10 L and uses high electricity consumption due to a 1000-W heater. Furthermore, Hendrarti (2020) developed a simpler yogurt incubator made of cardboard and lined with aluminum foil. The device has a thermostat set to the optimal temperature for yogurt bacteria and a light bulb that acts as a heater. This yogurt maker, however, is lacking of durability, inability to control room temperature, and inefficiency for large-scale yogurt production.

However, for local producers, yogurt maker machines with a capacity of <10 L are considered inadequate if yogurt production reaches 70-100 bottles or more than 10 L/d. Another thing is that the yogurt maker machine must be able to control the temperature and conditions of the yogurt during the incubation process. Yogurt production without using a machine, faces many challenges such as unstable temperature, high risk of contamination, and texture inconsistency of the produced yogurt (Koswara, 2009). Therefore, the aim of this study is to design a yogurt maker machine with a capacity of 15 L and working temperature of 37–45 ℃ for local yogurt producers to produce better quality yogurt.

2. MATERIALS AND METHODS OF RESEARCH

The production and testing of the yogurt maker were conducted at the Central Research and Workshop Laboratory, Department of Agricultural Engineering, Faculty of Agriculture (FP), Syiah Kuala University (USK). Meanwhile, the production of plain yogurt was carried out at the Product Development and Pilot Plant Laboratory, Department of Agricultural Product Technology, FP, USK. The research was conducted from January to June 2023.

2.1. Materials and Steps

Various materials were used in designing the yogurt maker including a heater, DS18B20 temperature sensor, RTC (Real-Time Clock), ESP32 microcontroller, Relay 4 channel shield, 12 V fan, 20x4 LCD, jumper cables, micro-USB cable, knife, scissors, measuring tape, and hot glue. Meanwhile, the materials used in making plain yogurt during the tool testing phase are UHT milk, yogurt starter, skim milk, and granulated sugar.

The research was conducted by designing and testing a prototype of yogurt maker device. The prototype design consisted of four stages: animation design, system design, system flow, and assembly. Meanwhile, the device testing comprised of temperature accuracy reading, temperature response, and making plain yogurt.

2.1.1. Animation design

The yogurt maker device consists of two main parts, namely the tube or container to hold yogurt with a capacity of 15 L and a box that serves as an incubator. The tube is made of stainless steel material, which is resistant to rust, easy to clean, non-reactive, withstands high temperatures, and environmentally friendly. The animation design of the tube, used as a container for milk and yogurt, has a hole diameter of 25 cm, a height of 35 cm, and a stainless steel thickness of 0.5 mm. Furthermore, the yogurt maker box is made of iron plates, which have advantages in terms of device durability, heat properties, durability, and ability to maintain better room temperature incubation conditions. The yogurt maker box is assembled using 32 iron rods measuring 50 cm each, resulting in a total size of 35 cm x 45 cm. The specifications of the yogurt maker can be seen in Table 1.

Table 1. Specifications of the yogurt maker device

Component type	Description
Yogurt capacity	15 L
Container size	25cm x 35 cm
Incubator box	35 cm x 45 cm
Power consumption	424 W
Heating element type	Heater
Incubator material	Stainless steel
Microcontroller	ESP32
Temperature sensor	DS18B20

The design of the yogurt maker machine consisted of several other components, such as:
1. Heater (PTC Insulative Corrugated Heater), functions as a 50 watt 220V power heater.
2. Temperature sensor DS18B20, functions as a temperature reader on the device.
3. RTC (Real-Time Clock) DS3231 Series SN I2C, functions as a time regulator on the device component.
4. ESP32 microcontroller, functions as a support for the device's performance system, which has several important features such as WiFi, dual-core CPU, Bluetooth, cryptography capabilities, interfacing, memory, and low power consumption.
5. Relay 4 channel shield, functions as the central control of the device's operation system.
6. 12V fan, functions as a cooler for the device's room temperature.
7. 20x4 LCD, functions as a display related to information from the device.
8. Jumper cables, functions as connectors or connections between components inside the device.
9. Micro USB, functions as a connection for data transfer processes on the device.

2.1.2. System design

The system design of the yogurt maker aims to provide an overview of the mechanism of using the device. The DS18B20 temperature sensor is responsible for reading the temperature inside the yogurt maker, while the RTC functions to regulate the time on the yogurt maker (Manab, 2008). Readings from both sensors will be sent to the ESP32 microcontroller. The temperature values from the microcontroller are then forwarded to the 20x4 LCD for clear display and easy understanding of the obtained numerical values. Subsequently, the heater is activated when the temperature inside the device is below the set lower temperature limit. Conversely, the heater will be turned off and the fan will be activated when the temperature inside the device exceeds the upper setpoint temperature. The temperature set is between 45-46°C. This is done to maintain a stable temperature inside the device.

2.1.3. System flow

The system flow is the mechanism of how a series of devices (hardware and software) work as a whole, starting from the device turning on until it turns off (ON to OFF) and vice versa (Hermawan, 2018). A closed loop control system is a control system whose output has a direct influence on the controlling action (Stanto, 2014). The system flow of this yogurt maker device starts with assembling the electronic components, which consist of a 5V 4-channel relay, ESP32 module, DS18B20 temperature sensor, RTC, 12V fan (along with 12VDC connecting components), 220V heater, 20x4 LCD, and 220VAC adapter cable (Figure 1). All electronic components will perform their respective functions and tasks according to the predetermined rules and are organized using the Arduino IDE application. The main component of this system is the ESP32, which acts as the brain or central unit of the yogurt maker device system to control the flow/mechanism of the electronic component circuitry in the yogurt maker device. The temperature sensor DS18B20 readings inside the yogurt maker box during yogurt making over a period of 12 h are compared with a thermometer as a reference device for temperature measurement (Prasetyo *et al*., 2017) as depicted in Figure 1 (right).

2.1.4. Assembly of yogurt maker components

The yogurt maker was assembled by connecting the microcontroller and other components using jumper cables. The Arduino IDE application was used to program the microcontroller and then libraries were added according to several components such as LCD, DS18B20 sensor, ESP32 module, and database. All these components were then transferred to the yogurt maker box. The tube (yogurt maker container) was placed inside the yogurt maker box (incubator).

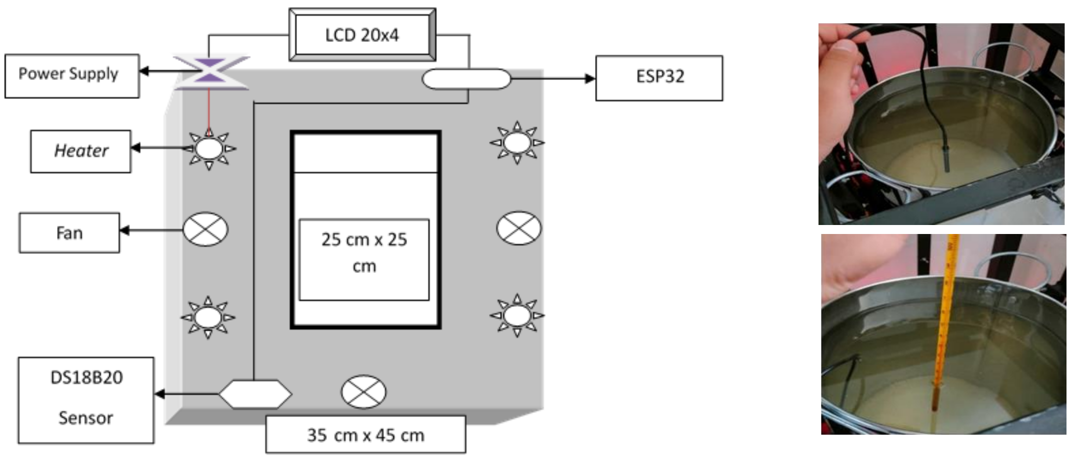


Image 1. Sketch of yogurt maker device creation (left), and temperature measurement (right)

2.1.5. Temperature reading accuracy test

The testing is conducted by comparing the readings between the DS18B20 sensor inserted into the tube and a thermometer. The accuracy of the device is assessed within the temperature range of 37–45℃.

2.1.6. Temperature responsiveness test

The testing is conducted to observe the automatic control system (DS18B20 sensor) on the yogurt maker to ensure that the temperature matches the predetermined setpoint (37-45 ℃). The yogurt maker is also tested using a sample of mineral water totaling 15 L for 12 h with three repetitions.

2.1.7. Plain yogurt making test

Plain yogurt is made following the procedure from (Sari, 2019) with modifications. Five liters of UHT milk are heated in the tube to 45 ℃. Then, the milk is mixed with 175 g of skim milk, 60 g of sugar, and 80 ml of yogurt starter. Next, the mixture is placed into the yogurt maker box. Fermentation occurs for 12 h. The performance of the yogurt maker temperature control is observed for 12 h and repeated three times.

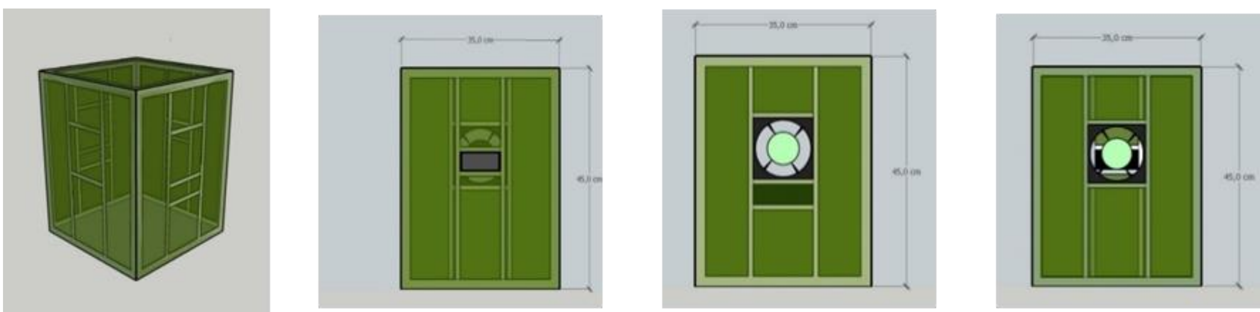
2.2. Data Analysis

The data obtained from the temperature reading accuracy test, temperature responsiveness test, and plain yogurt making are analyzed using standard deviation. A T-Test is used to compare the differences between the two types of sensor measuring devices (DS18B20 with thermometer).

3. RESULTS AND DISCUSSION

3.1. Yogurt Maker Machine Design

The yogurt maker consists of two main parts: a tube to accommodate a 15-L yogurt capacity and an incubator to maintain temperature during the manufacturing process. All devices are attached and inserted into the yogurt maker box, starting from the 4-channel relay, ESP32 module, DS18B20 sensor, RTC, heater, fan, 20x4 LCD, and stainless steel container. All designed main parts are then combined into one unit. The yogurt maker box is coated with acrylic material to protect the components inside the yogurt maker box and also to maintain temperature and humidity conditions inside the space. Acrylic sheets used on the 6 sides of this yogurt maker box have different sizes. The top and bottom sides of the box have dimensions of 35 cm x 35 cm, while the other sides (right, left, front, back) have dimensions of 35 cm x 45 cm (Figure 2). The result of the yogurt maker design can be seen in Figure 3.



(a) (b) (c) (d)

Figure 2. Animation design of the yogurt maker: (a) four sides, (b) front view, (c) right and left view, and (d) back view.

(a) (b) (c)

Figure 3. Final result of the yogurt maker model on: (a) front view, (b) right and left sides, and (c) back view.

3.2. Design And System Flow

The system flow is the mechanism of how a series of devices (hardware and software) work as a whole, starting from the device turning on until it turns off (ON to OFF) and vice versa (Hermawan, 2018). The system flow of the yogurt maker begins with assembling the electronic components, including a 5V 4-channel relay, ESP32 module, DS18B20 temperature sensor, RTC, 12V fan (along with 12VDC connecting components), 220V heater, 20x4 LCD, and 220VAC adapter cable, as shown in Figure 4. All these electronic components will perform their respective functions and tasks according to predetermined rules and are organized using the Arduino IDE application. The main component

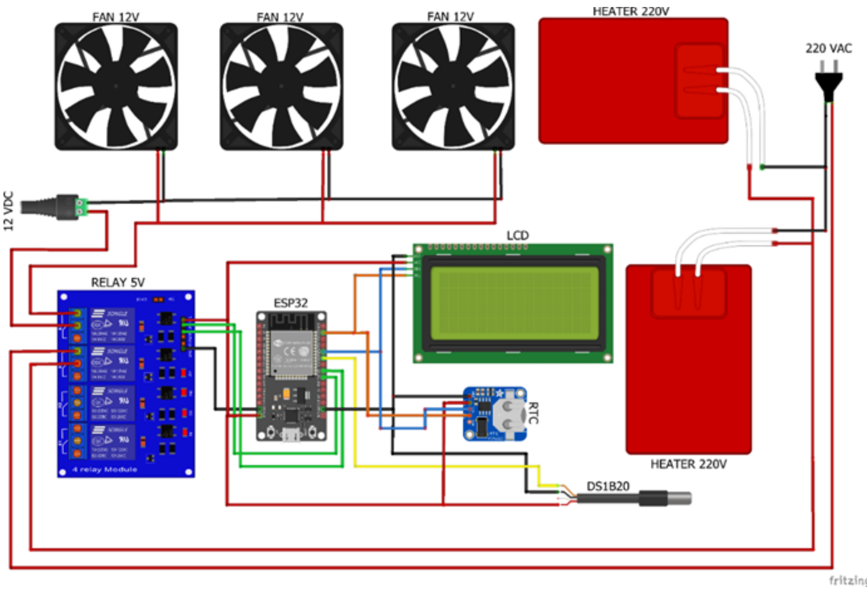


Figure 4. Design of the system flow of the electronic component circuitry of the yogurt maker device. (Note: Red = Electric Current, Yellow = Data PIN, Green = Data PIN, Blue = Serial Data (SDA), Orange = Serial Clock (SCL), Black = GND (Ground).

of this system is the ESP32, which acts as the brain or central unit of the yogurt maker system to control the flow/mechanism of the electronic component circuitry in the yogurt maker device.

In the yogurt maker machine, there are 4 sides for placing electronic components, with the ESP32 module installed at the back along with the 4-channel relay. Then, the fan and heater are located on the left and right sides, and there is 1 fan positioned at the back above the ESP32 module. Meanwhile, at the front position, there is a 20x4 LCD. First, the DS18B20 temperature sensor module is mounted on pin D19 of the ESP32. The DS18B20 temperature sensor works by detecting the conditions in the incubation room during the fermentation process and sending data to the ESP32 in real-time in the form of voltage. Then, the voltage data is read and converted by the ESP32 into digital numerical data (Mufida *et al*., 2020), which is then forwarded and displayed on the 20x4 LCD. The AC (Alternating Current) electrical current entering is 220V, which then enters the cable flow. The AC electrical current is then continued to the adapter and converted into 12V in the form of DC (Direct Current). In addition, the AC electrical current also enters the heater, which functions to heat the fermentor, and the fan to cool/stabilize the conditions inside the yogurt maker room. After coming out of the adapter, the DC electrical current then enters the ESP32 and stepdown, so that the outgoing electrical current becomes 5V, which then flows to other electronic components.

Furthermore, the relay is an electronic component in the form of an electronic switch that is operated by electrical current (Sahib & Ayu, 2019). In principle, the relay is a switch lever with a wire winding on an iron rod (solenoid) nearby. When the solenoid is energized with 5V electrical current, the lever (contact) will be attracted due to the electromagnetic force generated on the solenoid, so the switch contact will close. When the current is stopped, the magnetic force will disappear, the lever returns to its original position, and the switch contact opens again (Purwandaru *et al*., 2021). The relay component is connected to pin D5 of the ESP32 for the 220VAC heater in ON mode, while D17 is for the 12VDC Fan also in ON mode. The 220VAC electrical current connected is then continued to the heater as a heater and fan as a cooler. The heat generated by the heater is according to the setpoint temperature value previously determined. The temperature during incubation must be stable at around 40-45 °C (Rangkuti, 2016).

The LCD 20x4 component is connected to pins D21 and D22 of the ESP32. A 5V DC power supply is also provided to the LCD with the help of the I2C component. The I2C (Inter-Integrated Circuit) component serves to simplify the power supply to the LCD (Simbar & Syahrin, 2016) using two wires for transmission: the SCL (Serial Clock) wire functions as the serial data transmission, and the SDA (Serial Data) wire serves as the synchronization line. The SCL wire is connected to pin D22, and the SDA wire is connected to pin D21. Additionally, the RTC (Real Time Clock) is also connected to the 5V DC power supply with two connected wires: SDA to pin D21 and SCL to pin D22. The overall arrangement of electronic components can be seen in Figure 4. The pin configuration and usage allocation in the device circuitry are shown in Table 2.

Table 2. Configuration allocation and PIN usage in the device circuitry.

Main Devices	Other Devices
ESP32	**LCD 20x4**
GND	GND
5V	VCC
D21	SDA
D22	SCL
	Sensor DS18B20
GND	GND
VIN (5V)	VCC
D19	SDA
	RTC
GND	GND
VIN (5V)	VCC
D21	SDA
D22	SCL
	Relay
GND	GND
5V	VCC
D5	IN1
D17	IN2

Table 3. Comparison of DS18B20 temperature testing with thermometer

Testing Time	DS18B20 Sensor	Thermometer
09.00	31.05°C ± 0.13	31°C ± 1
10.00	31.50°C ± 0.20	31°C ± 1
11.00	32.10°C ± 0.13	32°C ± 1
12.00	32.45°C ± 0.15	32°C ± 1
13.00	32.90°C ± 0.10	32°C ± 1
14.00	33.40°C ± 0.10	33°C ± 1
15.00	33.95°C ± 0.10	33°C ± 1
16.00	34.60°C ± 0.10	34°C ± 1
17.00	35.20°C ± 0.10	35°C ± 1
18.00	35.80°C ± 0.10	35°C ± 1
19.00	36.55°C ± 0.09	36°C ± 1
20.00	37.30°C ± 0.05	37°C ± 1
21.00	37.95°C ± 0.05	37°C ± 1

Note: T-test: 0.00006 (P-value ≤ 0.05)

3.3. Temperature Reading Accuracy

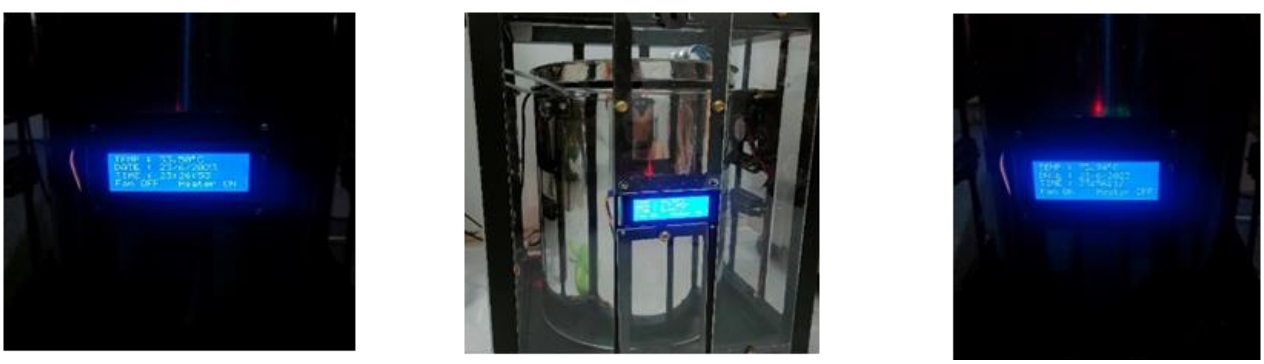
The temperature readings displayed by the yogurt maker device can be seen in Table 3. Based on Table 3, the difference of temperature reading between the DS18B20 sensor and the thermometer varies from 0.35 to 0.75°C. The T-test results yielded a value of 0.00006, which is far below (≤ 0.05), indicating a significant difference between the DS18B20 sensor and the thermometer. The temperature readings on the thermometer are shown in integer numbers (not specific) because the thermometer displays readings in multiples of 1 and uses lines for each interval, resulting in less detailed temperature readings. On the other hand, when using the DS18B20 sensor, the temperature readings display two decimal places, providing more precise and accurate temperature readings. This is consistent with the calibration of the DS18B20 sensor conducted by (Purwandaru *et al*., 2021), which states that the sensor works well and is sufficiently accurate within the temperature range of 30-56℃. The temperature testing using the DS18B20 sensor and the thermometer (see Figure 5) was performed manually and under the same water temperature conditions.

3.4. Temperature Response

The results of temperature checks conducted every hour can be seen in Table 4. Calibration of the DS18B20 temperature sensor was performed using samples of mineral water with the target temperature ranging from 37-45 ℃. Based on Table 4, the average temperature of the yogurt maker during fermentation remained within the targeted temperature range (37-45 ℃). However, the decrease in temperature observed every hour and day is suspected to be due to several factors such as insufficient heater power (only 100 watts), occasionally unstable electrical power, and the presence of some open gaps in the yogurt maker device, resulting in uneven distribution of heat. These results differ significantly from the yogurt incubator device made by Amar *et al*. (2018), where the yogurt incubator device performed very well due to the use of a heater with a power of up to 1000 watts and the incubator room temperature being able to reach a maximum temperature of 44±1 ℃ within 7 h. Additionally, the yogurt incubator chamber was tightly sealed, and the electrical flow during incubation was stable.

Table 4. Comparison of yogurt maker temperature over 12 h for 3 days.

No	Testing Time	Average Incubator Temperature	Standard Deviation
1	09.00	45.40	± 0.38
2	10.00	43.00	± 2.72
3	11.00	42.17	± 3.28
4	12.00	41.05	± 3.30
5	13.00	40.36	± 3.02
6	14.00	39.66	± 2.79
7	15.00	39.12	± 2.65
8	16.00	38.62	± 2.49
9	17.00	38.82	± 3.00
10	18.00	38.83	± 3.33
11	19.00	38.71	± 3.64
12	20.00	38.61	± 3.82
13	21.00	38.23	± 3.53



(a) (b) (c)

Figure 5. The results of the yogurt maker's response at various temperatures: (a) <37℃, (b) 37-45℃, and (c) >45℃

The results of the yogurt maker's response to various temperature ranges are shown in Figure 5. The testing results indicate that when the device is turned on (ON), the heater will immediately activate because the initial ambient temperature of the yogurt maker is below 37 °C. When the ambient temperature of the yogurt maker is between 37 and 45 °C, the heater will remain on, and the fan will be off. When the ambient temperature of the yogurt maker exceeds

45 °C, the fan will turn on (ON), and the heater will turn off (OFF). This indicates that the designed yogurt maker functions properly. If the yogurt maker is capable of incubating, then the tool is suitable for use (Yunas & Ali, 2020).

3.5. Making Plain Yogurt

Plain yoghurt has a sharp sour taste and aroma (Wulanningsih, 2022). The temperature testing during the plain yogurt making process can be observed in Table 5. Based on Table 5, the temperature of the yogurt maker tends to decrease every hour. However, overall, the average temperature remains between 39-45 °C. The milk fermentation with good temperature stability lasts between 4-8 h because the incubator temperature is stable around 40-42 °C. Furthermore, the plain yogurt produced using this yogurt maker has characteristics such as thick texture, slightly acidic taste, unique aroma, and homogeneous consistency. The plain yogurt produced meets the requirements of SNI 2981:2009, where the desired characteristics of plain yogurt include homogenous consistency, semi-solid appearance, and acidic/distinct aroma and taste. According to Tjatur & Dyah (2017), the characteristic features of plain yogurt are white color, smooth texture, slightly thick/semi-liquid texture with a very acidic taste, good palatability, and high digestibility.

Table 5. Comparison of yogurt temperature over 12 h.

No	Testing Time	Average Incubator Temperature	Standard Deviation
1	09.00	45.48	± 0.08
2	10.00	44.30	± 0.10
3	11.00	43.36	± 0.10
4	12.00	42.44	± 0.11
5	13.00	41.32	± 0.12
6	14.00	40.53	± 0.12
7	15.00	39.73	± 0.13
8	16.00	39.63	± 0.12
9	17.00	39.34	± 0.08
10	18.00	38.94	± 0.04
11	19.00	39.32	± 0.03
12	20.00	39.44	± 0.04
13	21.00	39.68	± 0.02

4. CONCLUSIONS

The conclusion drawn from this research is as follows: the design and construction of the yogurt maker model have been successfully carried out with specifications including a capacity of 15 L, container size of 25 cm x 35 cm, and incubator box size of 35 cm x 45 cm. The design and system flow of the electronic circuitry in the yogurt maker consist of ESP32, LCD 20x4, DS18B20 temperature sensor, RTC, 4 Channel Relay, heater, and fan. Testing the accuracy of temperature readings using the DS18B20 sensor proved to be more precise and accurate compared to using a thermometer (P-value ≤ 0.05). Testing the response to the yogurt maker's temperature can be conducted for 12 hours within the temperature range of 37℃-45℃, with the optimum incubation time being 4 to 8 hours. Several additional features such as increasing the heater wattage to 500-1000 watts, adding a buzzer, on/off switch, water heater, stirrer, and remote control via an IoT system could be implemented for further development of the yogurt maker machine.

REFERENCES

Amar, A., Muhami, M., Hendrawan, I., & Tampubolon, E.S. (2018). Incubators for household-scale yoghurt production in improving production process in Kuningan District. *MITRA: Jurnal Pemberdayaan Masyarakat*, ***2***(2), 80–91. https://doi.org/10.25170/mitra.v2i2.102.

BSN (Badan Standarisasi Nasional). (2009). SNI 2981: *Yoghurt*. Badan Standarisasi Nasional, Jakarta.

CAC (Codex Alimentarius Commission). (2003). *Codex Standard for Fermented Milks*: *Codex STAN 243*. FAO/WHO Food Standards.

Gunawan, B. & Sukardi, S. (2020). Rancang bangun pengontrolan suhu dan kelembaban pada proses fermentasi tempe berbasis Internet of Things. *JTEIN: Jurnal Teknik Elektro Indonesia*, ***1***(2), 168–173.

Hasanah, M. & Rosma, F. (2021). Pelatihan teknik pembuatan yoghurt untuk siswa MAS Insan Qurani Aceh Besar. *BAKTIMAS : Jurnal Pengabdian Pada Masyarakat*, ***3***(4), 161-167.

Hendrarti, E., Susanto, S., & Nurmaningsih, N. (2020). Respons wanita tani terhadap teknologi pembuatan yoghurt menggunakan inkubator sederhana berbahan kardus. *Prosiding Seminar Nasional Polbangtan Yogyakarta Magelang* (ISBN : 978-623-95866-0-3): 425-433

Hermawan, L. (2018). Rancang bangun sistem monitoring budidaya jamur tiram berbasis Arduino. *JATI: Jurnal Mahasiswa Teknik Informatika*, ***2***(2), 161-167.

Koswara, I.S. (2009). *Teknologi Pembuatan Yoghurt*. E-bookPangan.com: 2-14.

Layadi, N., Sedyandini, P., & Soetaredjo, F.E. (2009). Pengaruh waktu simpan terhadap kualitas soyghurt dengan penambahan gula dan stabiliser. *Jurnal Widya Teknik*, ***8***(1), 1-11.

Manab, A. (2008). Physical properties of yogurt during storage at 4°C. *JITEK: Jurnal Ilmu dan Teknologi Hasil Ternak*, ***3***(1), 52-58.

Maharani, F., & Ayuningtyas, R.D. (2018). Pelatihan pembuatan yoghurt di Kecamatan Pedurungan Kota Semarang. *Jurnal ABDIMAS UNWAHAS*, ***3***(2), 5-9. https://doi.org/10.31942/abd.v3i2.2495.

Mufida, E., Rian, S.A., Rivai, A.K., & Indri, P.R. (2020). Perancangan alat pengontrol pH air untuk tanaman hidroponik berbasis Arduino Uno. *INSANtek: Jurnal Inovasi dan Sains Teknik Elektro*, ***1***(1), 13-19.

Mustika, S. & Yasni, S. (2019). Pembuatan yoghurt susu sapi segar dengan penambahan puree ubi jalar ungu. *JPTK*: *Jurnal Pendidikan Teknologi Kejuruan*, ***2***(3), 97-101.

Prasetyo, M., Imam, S., Siti A. M., & Purwadi. (2017). Penerapan metode FMEA dan AHP dalam perumusan strategi pengelolaan resiko proses produksi yoghurt. *Jurnal Teknologi Pertanian*, ***18***(1), 1-10.

Purwandaru, K., Faturrohman, D.E., Putri, A.R., Maghfiroh, R.P., Ridhollah, M.R., & Dewi, L.K. (2021). Rancang bangun fermentor yogurt susu kambing Etawa dengan sistem kontrol sensor pH 4502C dan suhu DS18B20 berbasis Arduino UNO R3. *Jurnal Keteknikan Pertanian Tropis dan Biosistem*, ***9***(3), 281–291. https://doi.org/10.21776/ub.jkptb.2021.009.03.10.

Rangkuti, K. (2016). IbM kelompok ternak sapi : Pembuatan yoghurt dari susu sapi skala rumah tangga. *Jurnal Prodikmas: Hasil Pengabdian Kepada Masyarakat*, ***1***(1), 1-10.

Sahib, J., Miskiyah, M., & Ayu, K. (2019). Penambahan enkapsulan dalam proses pembuatan yoghurt powder probiotik dengan metode *spray dyring*. *Jurnal Penelitian Pascapanen Pertanian*, ***16***(2), 56-63.

Sarah, S., Indarti, E., & Yunita, D. (2021). Pengujian starter yoghurt (*Streptococcus thermophilus* dan *Lactobacillus bulgaricus*) serta ekstrak jamblang (*Syzygium cumini L*.) pada kasus niyoghurt jamblang yang telah rusak. *Jurnal Ilmiah Mahasiswa Pertanian*, ***6***(1), 37–43.

Sari, D., Purwadi, P., & Thohari, I. (2019). Upaya peningkatan kualitas yoghurt set dengan penambahan pati kimpul (*Xanthosoma sagittifolium*). *Jurnal Ilmu-Ilmu Peternakan*, ***29***(2), 131–142. https://doi.org/10.21776/ub.jiip.2019.029.02.04

Simbar, R.S.V., & Syahrin, A. (2016). Prototype sistem monitoring temperatur menggunakan Arduino Uno R3 dengan komunikasi wireless. *Jurnal Teknik Mesin*, ***05***, 48-53. https://doi.org/10.22441/jtm.v5i4.1225.

Stanto, N.H., Rif'an, M., & Rahmadwati, N.A. (2014). Pengendalian suhu dan waktu proses fermentasi dalam pembuatan yoghurt berbasis *Programmable Logic Control* dan *Human Machine Interface*. *Jurnal Mahasiswa TEUB*, ***2***(3), 1-8.

Sumarmono, J. (2016). *Yogurt & Concentrated Yogurt*: *Makanan Fungsional Dari Susu*. Lembaga Penelitian dan Pengabdian Kepada Masyarakat, Universitas Jenderal Soedirman, Purwokerto.

Tamine, A.Y., & Robinson, R.K. (2007). *Yogurt: Science and Technology*. Cambridge University, England.

Tjatur, A.N.K., & Dyah, L.A. (2017). *Susu Fermentasi Yoghurt*. Media Nusa Creative, Malang.

Utami, D., & Hariadi, S. (2020). Teknologi pengolahan yoghurt sebagai diversifikasi produk susu kambing pada kelompok ternak Desa Wonosari Kecamatan Tempurejo Kabupaten Jember. *PRIMA*, ***4***(1), 30. https://doi.org/10.20961/prima.v4i1.39531.

Wulanningsih, U.A., (2022). Pelatihan pembuatan yoghurt sapi dengan metode sederhana menggunakan *Lactobacillus bulgaricus* dan *Streptococcus Thermophilus*. *Jurnal Cerdik: Jurnal Pendidikan dan Pengajaran*, ***1***(2), 66-78.

Yunas, R.K., & Ali, B.P. (2020). Sistem kendali suhu dan kelembaban pada proses fermentasi tempe. *JTEV: Jurnal Teknik Elektro dan Vokasional*, ***6***(1), 103-113.