Telemonitoring Based Waste Cooking Oil Quality Detection and Sorting System

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Abstract — In this research, a tool is made that can determine the quality of used cooking oil based on the parameters of color, pH, free fatty acid content and turbidity. The detector is equipped with a TCS3200 sensor to detect color, a pH sensor to detect pH, a conductivity sensor to detect free fatty acid levels and a turbidity sensor to detect turbidity in used cooking oil. For data transmission, the ESP32 module is used and the output data can be viewed and monitored via a 16x2 LCD and a website on a smartphone or computer. The results of the tests that have been carried out are sensor accuracy, the success of data transmission. The TCS3200 color sensor has an average reading error of 0.44%, the pH acidity sensor has an average reading error of 0.4%, the conductivity sensor has an average reading error of 0.46% and the turbidity turbidity sensor has an average reading error of 0.53%. The system created has a good quality of information delivery and successful data transmission when testing delay and packet loss. The success rate of sending data from ESP32 to the Webserver is 92.4% and the average delay in sending data is 0.0025 ms.

Keywords — ***Cooking Oil, Conductivity Sensor, ESP32, TCS3200 Sensor, Ph Sensor, Turbidity Sensor***

I. PENDAHULUAN

Indonesia is a country with various natural resources, one of which is palm oil. Based on the statistics of the Directorate General of Indonesian Plantations, the Volume and Value of Palm Oil Exports (CPO) from 2015-2017 showed a decrease from 26,467,564 tons in 2015 to 24,150,232 tons in 2016. This is estimated to occur due to the large amount of palm oil consumption. domestic [1]. Palm oil is one of them used as an ingredient of cooking oil which is used as an ingredient in food processing [2].

Cooking oil is one of the necessities in the household for cooking and the cooking oil used must have good quality, namely good nutritional content. However, the use of cooking oil has a limit, namely it can only be used a maximum of three times [3].

Cooking oil that has been used many times (used) called used cooking oil will become household waste. Used cooking oil contains free fatty acids due to periodic heating which is harmful to the body [4]. As a result of the very high price of cooking oil, people still use used cooking oil for daily cooking, even many people do the conventional method, one of which is by purifying used cooking oil by absorbing wood charcoal so that the used cooking oil is clean and used again for cooking, even though it is very expensive. dangerous for health and can cause a number of diseases, such as stroke, coronary heart disease, hypertension, and cancer. However, many people do not care or realize it [5].

The quality of used cooking oil can be determined by testing several parameters. Parameters that are quite important to determine the quality of used cooking oil based on Indonesian quality standards of used cooking oil are color parameters [6], acidity (pH) [7], free fatty acid levels [8] and turbidity [9]. These four parameters need to be emphasized so that people can know and control the quality of used cooking oil that is suitable for reuse. These parameters can be detected using several types of technology, namely sensors [10] and microcontrollers [11].

Based on the problems and technological sophistication, the authors are interested in taking this title because they are able to make a quality detection system for used cooking oil according to the parameters listed using several sensors, namely the TCS3200 sensor [12] to detect color, the water pH sensor to detect pH [13], the conductivity sensor [14] to detect free fatty acids and turbidity sensor to detect turbidity [15] and the ESP32 microcontroller [3][12][15] as the control center of the system for controlling and monitoring all sensors Then the output data can be viewed and monitored via a 16x2 LCD and a website via a smartphone or computer. In this study, a system that can support is proposed, namely research with the title "Telemonitoring Based Waste Cooking Oil Quality Detection and Sorting System". With this research, it is hoped that it will make it easier for the public to know the quality of used cooking oil whether the measured used cooking oil is feasible or not suitable for re-consumption.

II. RESEARCH METHODS

This sub-chapter describes the research method from the title of the thesis "Telemonitoring Based Waste Cooking Oil Quality Detection and Sorting System".

A. *Stages of Research*

Figure 1 shows that the stages of research carried out as an initial stage in conducting research are shown below. Everything related to research must be planned in advance, from finding references to making reports.

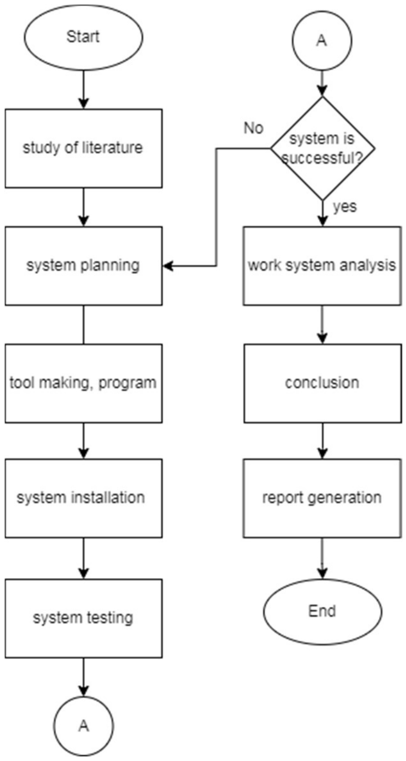

Figure 1. Research Stages

B. *System Design*

In the system design section, a description of the system planning that will be made and identification of information needs will be explained based on the results of observations and literature studies that have been carried out, as shown in Figure 2.

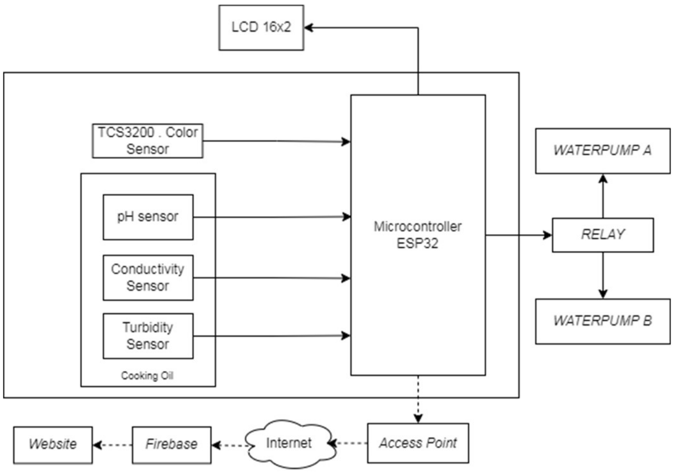

Figure 2. System Block Diagram

Figure 2 is a block diagram of a system design regarding a series of components, with the following explanations:

1. The TCS3200 color sensor functions to detect the color of the tested cooking oil and the data will be sent to a website controlled by the microcontroller. Output data can also be viewed on the 16x2 LCD.
2. The pH sensor functions as a detector for the acidity of the used cooking oil, whether the acidity in the used cooking oil has a low or high pH and the data will be sent to a website controlled by the microcontroller. Output data can also be viewed on the 16x2 LCD.
3. The conductivity sensor functions as a detector of free fatty acid levels in the tested cooking oil and the data will be sent to a website controlled by a microcontroller. Output data can also be viewed on the 16x2 LCD.
4. The Turbidity sensor functions as a turbidity detector in the used cooking oil and the data will be sent to a website which is controlled by a microcontroller. The output data can also be viewed on the 16x2
5. LCD. The ESP32 microcontroller which functions as the control center of all systems for controlling and monitoring parameters of color, acidity (pH), free fatty acid levels and turbidity in the tested cooking oil.
6. The relay functions as a switch that works according to the sensor controlled by the microcontroller.
7. The water pump functions as a pump to transfer used cooking oil from one container to another.
8. 16x2 LCD serves to display the value of the sensor reading.
9. Firebase database serves to store data and send data to the website in real time.

C. *Flowchart System*

The flowchart of the planned system is shown in the Figure 3.

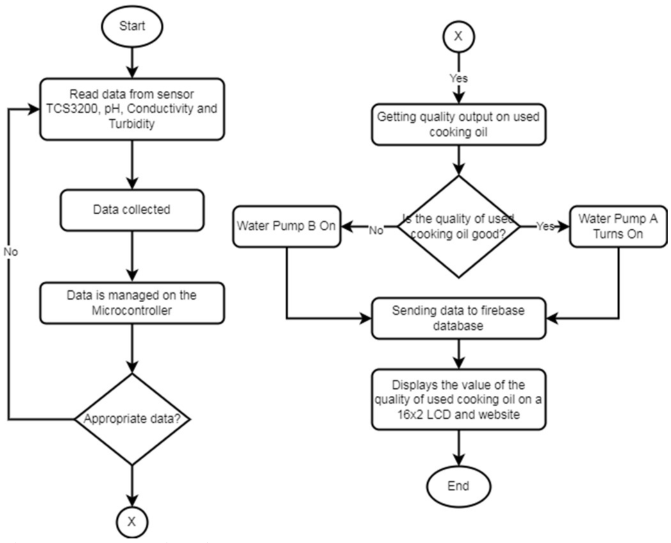

Figure 3. System Flowchart

The following is an explanation of the flowchart above.

1. The TCS3200 sensor detects color, pH detects acidity, conductivity detects free fatty acid levels and turbidity detects turbidity.
2. Data from sensors is collected.
3. The data that has been collected is managed on the microcontroller.
4. Are the data appropriate?. If the data match then get quality output on used cooking oil, if not it will return to number 2.
5. Does the output of the sensor value indicate the quality of used cooking oil is worthy of reuse? If yes, then water pump A turns on which will pump used cooking oil into a special container for used cooking oil that is suitable for reuse, if

not then water pump B turns on which will pump used cooking oil into a special container for used cooking oil that is not suitable for reuse.
6. Displays the value of the quality of used cooking oil on a 16x2 LCD.
7. Send and save data to firebase database.
8. Displays the value of the quality of used cooking oil on the website.

III. RESULT AND DISCUSSION

In this subchapter, the parameters that will be tested in the study are explained, namely the color parameter detected using TCS3200, the acidity parameter detected using the pH sensor, the free fatty acid level detected using the conductivity sensor, and the turbidity parameter detected using the turbidity sensor. , the accuracy of the TCS3200 sensor readings, pH, conductivity and turbidity during the process of detecting the quality of used cooking oil, the success of the actuator flame based on the reading value of each sensor, the success of delivery and the quality of information delivery from the ESP32 microcontroller to the firebase database which will be monitored through the website. The whole system circuit is shown in Figure 4.

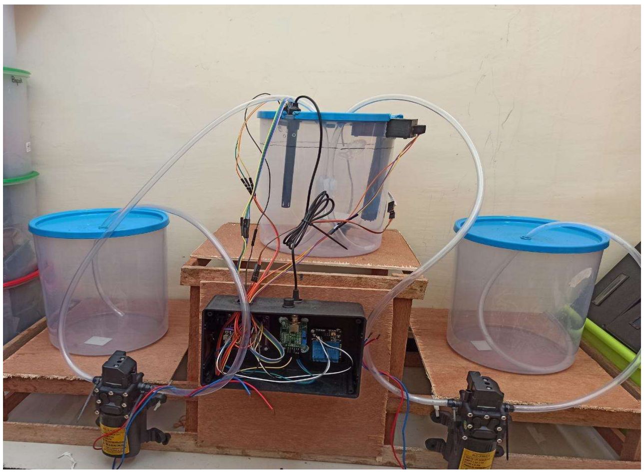

Figure 4. Overall System Circuit

Design of the software is making a monitoring website design to monitor the quality of used cooking oil according to the sensor output. The following is the web page layout for the used cooking oil quality detector in Figure 5.

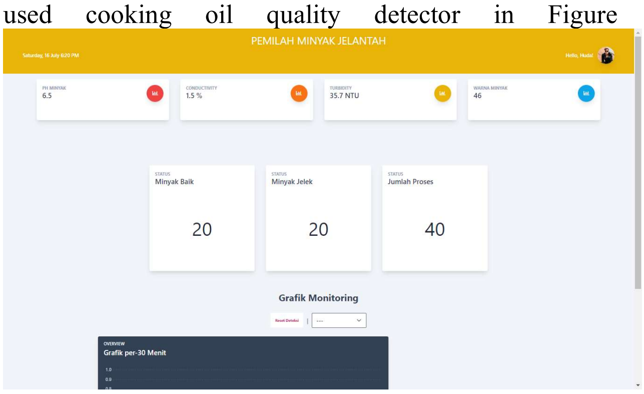

Figure 5. Website Monitoring System

A. *TCS3200 Color Sensor Measurement TCS3200*

Color sensor calibration was carried out to obtain the average TCS3200 sensor error value against the SNI standard value for cooking oil color. Calibration is done by comparing the output value of the TCS3200 sensor on the ESP32 with the SNI standard for cooking oil color to determine the accuracy of the TCS3200 sensor and to reduce the error deviation value on the sensor. Data retrieval was carried out with 10 repetitions using the SNI standard for cooking oil color as a comparison. The repetition of 10 times gives the average color quality according to the comparison used in Table 1.

TABLE 1.
TCS3200 SENSOR TEST RESULT

No	Red Color on SNI Standard Cooking Oil	Red Color on TCS3200 Sensor	Error Percentage (%)
1.	41	41.2	0.48
2.	42	42.2	0.47
3.	43	43.2	0.46
4.	44	44.2	0.45
5.	45	45.2	0.44
6.	46	46.2	0.43
7.	47	47.2	0.42
8.	48	48.2	0.41
9.	49	49.2	0.40
10.	50	50.2	0.40
Average Percentage Error			0.44

B. *Measurement of pH Sensor*

PH sensor calibration is carried out to obtain the average value of the PH sensor error on the value of the PH meter measuring instrument. Calibration is done by comparing the output value of the PH sensor on the ESP32 with a PH meter measuring instrument to determine the accuracy of the PH sensor and to reduce the error deviation value on the sensor. Data collection was carried out with 10 repetitions using a PH meter as a comparison. 10 repetitions gave an average acidity quality according to the comparison used in Table 2.

TABLE 2.
SENSOR TEST RESULT

No.	Standart Measuring Tool pH Meter	Sensor E-201 pH	Error Percentage (%)
1.	6.5	6.53	0.46
2.	6.6	6.62	0.30
3.	6.5	6.54	0.61
4.	6.6	6.63	0.45
5.	6.7	6.71	0.14
6.	6.6	6.61	0.15
7.	6.7	6.72	0.29
8.	6.8	6.85	0.73
9.	6.8	6.82	0.29
10.	6.9	6.94	0.57
Average Percentage Error			0.40

C. *Measurement of the Conductivity Sensor*

Calibration of the conductivity sensor was carried out to obtain the average error value of the conductivity free fatty acid level sensor against the SNI standard value of the free fatty acid content of cooking oil. Calibration is done by comparing the output value of the conductivity sensor on the ESP32 with the SNI standard for free fatty acid levels of cooking oil to determine the accuracy of the conductivity sensor and to minimize the error deviation value on the sensor. Data retrieval was carried out with 4 repetitions using the standard SNI for free fatty acids from cooking oil as a comparison. The repetition 4 times gave the quality of the average free fatty acid content according to the comparison used in Table 3.

TABLE 3.

CONDUCTIVITY SENSOR TEST RESULTS

No.	Free Fatty Acid Content on SNI Standard Cooking Oil (%)	Free Fatty Acid Level on Conductivity Sensor (%)	*Error Percentage (%)*
1.	0.5	0.502	0.40
2.	1	1.004	0.40
3.	1.5	1.507	0.46
4.	2	2.012	0.60
Average Percentage Error			0.46

D. *Turbidity Sensor Measurement Turbidity*

Sensor calibration is carried out to get the average result of the turbidity sensor error value against the turbidity meter measuring instrument. Calibration is done by comparing the output value of the turbidity sensor on the ESP32 with a turbidity meter measuring instrument to determine the accuracy of the turbidity sensor and to reduce the error deviation value on the sensor. Data retrieval is carried out with 10 repetitions using a turbidity meter as a comparison. 10 repetitions gave the average turbidity quality according to the comparison used in Table 4.

TABLE 4.

TURBIDITY SENSOR TEST RESULTS

No.	Turbidity on Standard Turbidity Meter (NTU)	Turbidity on the Turbidity Sensor (NTU)	*Error Percentage (%)*
1.	3.6	3.62	0.55
2.	3.6	3.62	0.55
3.	3.6	3.62	0.55
4.	3.7	3.72	0.54
5.	3.7	3.72	0.54
6.	3.8	3.82	0.52
7.	3.8	3.82	0.52
8.	3.8	3.82	0.52
9.	3.9	3.92	0.51
10.	3.9	3.92	0.51
Average Percentage Error			0.53

The results of the TCS3200 color sensor reading were carried out from 12.00 WIB to 16.00 WIB with measurements per 30 minutes in the category 2 times frying oil, 4 times frying and 6 times frying color value, the average change in color value decreased, the highest value was obtained at 12.00 WIB and the lowest value was obtained at 16.00 WIB. The pH sensor readings are carried out from 12.00 WIB to 16.00 WIB with measurements per 30 minutes in the oil category of 2 times of frying, 4 times of frying and 6 times of frying, the average change in pH value does not change drastically, changes in pH value are only the difference 0.1. The conductivity sensor readings were carried out from 12.00 WIB to 16.00 WIB with measurements per 30 minutes in the oil category of 2 times of frying, 4 times of frying and 6 times of frying, the average change in the conductivity value did not change drastically, the change in the conductivity value was only a difference of 0 ,1% to 0.2%. Turbidity sensor readings were carried out from 12.00 WIB to 16.00 WIB with measurements per 30 minutes in the oil category 2 times frying, 4 times frying and 6 times frying, the average change in turbidity value decreased, the highest value was obtained at 12.00 WIB and The lowest value was obtained at 16.00 WIB.

E. *Packet Loss*

Test Testing the success rate of data transmission can be done by calculating the packet loss sent from the ESP32 microcontroller to firebase.

TABLE 5.

PACKET LOSS TEST

Delivery of Packages to Firebase to-	Firebase data
1	Updated
2	Updated
3	Updated
4	Updated
5	Updated
6	Updated
7	Updated
8	Updated
9	Updated
10	Updated
11	Updated
12	Updated
13	Permanent

Based on Table 5 of the 13 packets sent, there was 1 failed package and 12 succeeded with a success percentage of 92.4% with a packet loss of 7.6% where the quality of package delivery was good.

F. *Delay*

Delay testing is needed to see if the communication system in this final project is running well or not. Wireshark can display several packets when doing live streaming, because the protocol used is TCP, therefore it must be filtered first. Do a filter according to the ip used. The IP used by ESP32 on the access point used is 192.168.3.18 and the Website IP is 13.107.21.200.

TABLE 6.

DELAY TESTING

Delivery of Packages to Firebase to -	IP ESP 32 (src)	IP Website Monitoring (dst)	*Delay* (ms)
1	192.168.3.18	13.107.21.200	0.0023
2	192.168.3.18	13.107.21.200	0.0024
3	192.168.3.18	13.107.21.200	0.0026
4	192.168.3.18	13.107.21.200	0.0028

Delivery of Packages to Firebase to -	IP ESP 32 (src)	IP Website Monitoring (dst)	*Delay* (ms)
5	192.168.3.18	13.107.21.200	0.0034
6	192.168.3.18	13.107.21.200	0.0035
7	192.168.3.18	13.107.21.200	0.0022
8	192.168.3.18	13.107.21.200	0.0027
9	192.168.3.18	13.107.21.200	0.0016
10	192.168.3.18	13.107.21.200	0.0032
11	192.168.3.18	13.107.21.200	0.0021
12	192.168.3.18	13.107.21.200	0.0014
13	192.168.3.18	13.107.21.200	0.0032
Average *Delay*			0.0025

Table 6 is the result of the packet calculation with the average delay obtained is 0.0025ms, it can be seen that the delay calculation result is very small. The smaller the delay, the better the quality of a data transmission because there is no delay in information.

IV. CONCLUSION

From the background, problem formulation, planning, implementation and discussion, it can be concluded that: Making a quality detection system and separator of used cooking oil using the TCS3200 sensor, pH sensor, conductivity sensor and turbidity sensor can be successful by monitoring several parameters of cooking oil, namely color, pH, free fatty acids, and turbidity. The TCS3200 sensor reads the color value, the pH sensor reads the pH acidity value, the conductivity sensor reads the free fatty acid value and the turbidity sensor reads the turbidity value in used cooking oil. The sensor is connected to the ESP32 microcontroller and managed on the firebase database via the internet. The TCS3200 color sensor has an average reading error of 0.44%, the pH acidity sensor has an average reading error of 0.4%, the conductivity sensor has an average reading error of 0.46% and the turbidity turbidity sensor has an average reading error of 0.53%. The system created has a good quality of information delivery and successful data transmission when testing delay and packet loss. The success rate of sending data from ESP32 to the Webserver is 92.4% and the average delay in sending data is 0.0025 ms.

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