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Monitoring Of Preservative Detection Devices In Market Foodstuffs

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Abstract **– Food safety is a crucial issue in Indonesia, especially regarding the use of hazardous preservatives such as formaldehyde in street food. Manual monitoring of formaldehyde use is often ineffective, so an automated system is needed to detect formaldehyde in real time. This study aims to develop an Internet of Things (IoT)-based formaldehyde detection system using an ESP32 microcontroller equipped with an ultrasonic sensor for automatic object detection. The detection data is sent to a Telegram-based platform. The test results show that this system is capable of accurately detecting objects at a distance of 0-20 cm and measuring voltage well to ensure the stability of the device. Testing of food samples shows the presence of borax in some street food, which proves the effectiveness of the system in detecting harmful preservatives and improving food safety.**

Keywords: Food safety, formalin, Internet of Things (IoT), ESP32, ultrasonic sensor, borax, automatic detection, market snacks

I. INTRODUCTION

Food safety is a crucial aspect that must be considered, especially in developing countries such as Indonesia, where traditional markets are still one of the main sources for people to obtain food and snacks. One serious problem that is often encountered is the use of hazardous chemicals such as formaldehyde as a food preservative. Formalin, which should only be used for non-consumption purposes, is often misused by unscrupulous traders to extend the shelf life of food products, especially market snacks [1]. The use of formaldehyde in food is very dangerous to human health. Short-term consumption of formaldehyde can cause irritation to the digestive system, nausea, vomiting, and in more severe cases, internal organ damage and even death. Therefore, early detection of formaldehyde in food is very important to protect consumers [2].

However, manual and periodic monitoring of formalin use by relevant authorities is often ineffective due to limited resources and the vast coverage area. Therefore, an automated system is needed that can detect the presence of formalin in real time and provide accurate information to authorities and consumers. In this context, Internet of Things (IoT) technology offers a potential solution. One important component in the development of IoT systems is microcontrollers such as ESP32, which are known for their powerful performance, wireless connectivity support, and efficient power consumption. By utilizing ESP32, a formaldehyde detection system can be designed to continuously monitor food and send the detection data to a web-based platform or mobile application for further analysis.

Previous research conducted by Yashinta Hardiyani, Sapto Nisworo & Hery Teguh Setiawan (2023) entitled Formalin Detection System Planning in Food. This study discusses formalin detection using a push button to start formalin detection on the test object so that the reading is not automatic when there is a test object to be detected. In addition, in this study, the data is only displayed on an LCD and is not yet connected to an IoT system. Furthermore, research conducted by Dany Pratmanto, Evita Nur Khasanah & Rousyati (2021) entitled "Formalin Detection Device in Fresh Fish Using an Arduino-Based Hcho Sensor." This research only displays the data on an LCD screen and uses a buzzer as an indicator when formalin is detected. Furthermore, it is not yet connected to an Android application, either via IoT or other means.

The development of this ESP32-based formalin detection tool is expected to be an important innovation in improving food safety in Indonesia. With this system, which uses ultrasonic sensors to automatically detect objects and is connected to the IoT, the public can be better protected from the dangers of consuming food containing formalin, and authorities can take more effective preventive measures. Therefore, the author was interested in conducting research entitled "Monitoring of Preservative Detection Devices in Market Food Stalls."

II. METHOD

Formalin is a solution of formaldehyde in water, which typically contains about 37% formaldehyde by volume with a small amount of methanol to prevent polymerization. Formalin is commonly used as a preservative and disinfectant in various industries, including medical, laboratory, and biological preservation. In the medical world, formalin is used to preserve biological specimens, while in industry, formalin is used in the production of resins, chemicals, and plastics.

Design a device that will be used to monitor formalin detection in market food snacks based on esp32, which has three stages, namely input, process, and output. All three stages have an equally important role. The following is a block diagram:

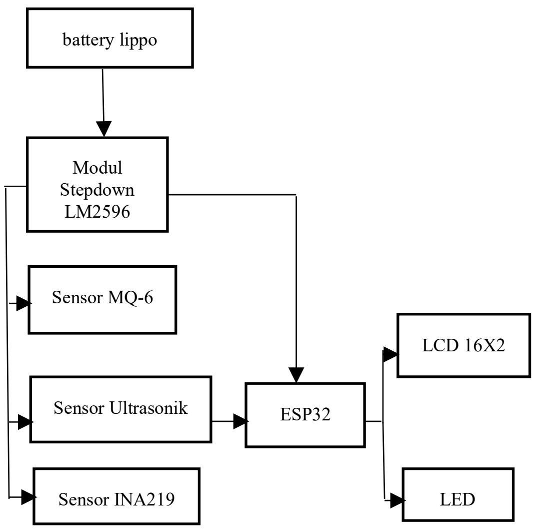

Figure 1. Blok Diagram

Figure 2 shows a block diagram of the research, which includes the input, process, and output components used. Some of the input components used are a lithium-polymer battery, ultrasonic sensor, HCHO sensor, and ina219 sensor. The process component is esp32, while the output components used are LCD and LED.

At this stage, the flowchart is created by designing a simple algorithm in the form of a flowchart to facilitate the creation of the tool. To ensure that the tool can be created smoothly, the algorithm in the tool is first illustrated with a flowchart, as shown in Figure 2.

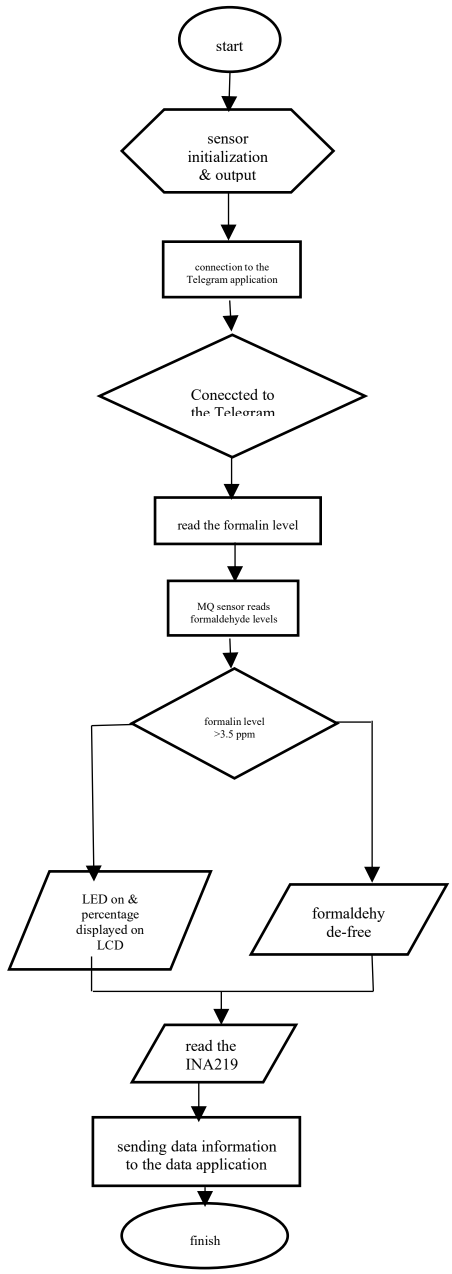

Figure 2. Flowchart

III. RESULT AND DISCUSSION

This measurement aims to determine the success rate of the tool that has been created, where testing will be carried out at several measurement points. The measuring point can be seen in the figure below:

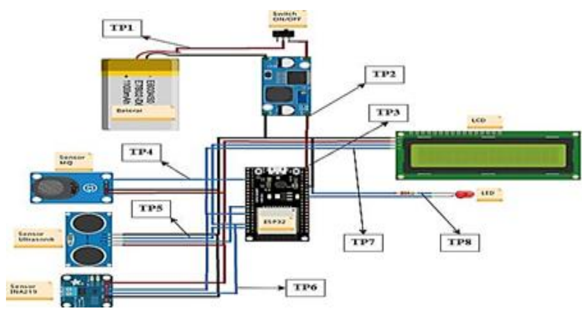

Figure 3. Measurement Point

Description:

TP 1 = Measurement point for voltage and current output from the battery.

TP 2 = Measurement point for voltage and current output from the battery to the step-down converter.

TP 3 = Measurement point for voltage and current output from the step-down converter to the ESP32.

TP 4 = Voltage measurement point on the MQ sensor.

TP 5 = Voltage measurement point on the ultrasonic sensor.

TP 6 = Voltage measurement point on the ina219 sensor.

TP 7 = Voltage measurement point on the 16x2 LCD.
TP 8 = Voltage measurement point on the LED.

These measurements were taken five times at each of the predetermined measurement points on the device. After taking five measurements, the average measurement was calculated using the following formula 3.

$$X=\frac{X_1+X_2+X_3+X_4+X_5}{n}=\frac{\sum X_i}{n} \qquad (1)$$

Where:

$\sum \boldsymbol{Xi}$ = is the total number of samples n = number of measurements

$\bar{X}$ = the average value

The results of the measurements and average calculations can be seen in Table 1.

Example of calculating the average voltage of TP 1 battery:

For measurements other than TP 1, all measurements were taken at the beginning of battery use. Table .1 shows the results of voltage and current measurements on the research equipment conducted by n

Table 1. measurement results

No	Measurement	Measure ment Point	Unit	Measurement results (volts DC)					Avera ge (Volt DC)	Description
				1	2	3	4	5		
1	Battery	TP1 (Battery Output)	VDC(Initial)	7.5	7.5	7.4	7.6	7.5	7.5	Input
			ImA(Initial)	205	204	204	205	205	204.6	Input
			VDC(1/2 hour)	7	7	7	7	7	7	Input
			ImA(1/2 hour)	200	199	198	199	197	198.6	Input
			VDC(1 hour)	6.7	6.6	6.7	6.7	6.7	6.7	Input
			ImA(1 hour)	185	186	185	185	185	185.2	Input
2	Step-down module	TP2	Vdc	5.01	5.02	5.04	5.03	5.05	5.03	Input
3	ESP32	TP3	Vdc	5.01	5.02	5.04	5.03	5.05	5.03	Output
4	MQ Sensor	TP4	Vdc	3.98	3.99	3.97	3.93	3.91	3.956	Output
				0.5	0.5	0.5	0.5	0.5	0.5	Output
5	Ultrasonic Sensor	TP5	Vdc	4.98	4.99	4.97	4.93	4.91	4.956	Output
6	INA219 Sensor	TP6	Vdc	3.98	3.99	3.97	3.93	3.91	3.956	Output
				2.5	2.45	2.5	2.55	2.5	2.5	Out put
7	16x2 LCD	TP7	Vdc	4.98	4.99	4.97	4.93	4.91	4.956	Output
8	LED	TP8	Vdc	3.3	3.3	3.25	3.3	3.26	3.282	Output

After getting the value of the measurement results, the next process is to perform calculations on the parts that can be calculated and then compared with the measurement results to find out the percentage error. The battery capacity used is 1500 mAh with a measured current of 205 mAh. To determine the battery energy used, the battery endurance calculation is performed using equation 2.2 in Chapter II which is

$$\text{Time (t)} = \frac{\text{capacity } battery}{\text{measured current}}$$

$$\text{Time (t)} = \frac{1500mAh}{205}$$

Time (t) = 7,31 h

To determine the percentage of measurement error, equation 4.2 can be used:

$$\%\text{error} \left| \frac{\text{Datasheet} - \text{Measurements}}{\text{Datasheet}} \right| \text{x } 100\% \quad \textbf{(3.4)}$$

The results of the measurements showed that the average voltage of TP 3was 5.03 volts.

$$\%\ error\ TP4:$$

$$\%\ error\ \frac{measurements - calculation}{measurements}\ x\ 100\%$$

$$\%\text{error} \left| \frac{5{,}03\text{Vdc} - 5\text{Vdc}}{5\text{Vdc}} \right| \text{x } 100\%$$

The measurement error is 0.006%. Using the same formula as above, we can find the % error at each specified measurement point (TP), and the results are shown in table 2. The measurement error is 0.006%. Using the same formula as above, we can find the % error at each specified measurement point (TP), and the results are shown in table 2.:

Table 2. Percentage Error

No	Measurem ent Position	Measurem ent Point		Unit	Data Sheet (V)	Average Measureme nt (V)	Error (%)	Description
1	Battery	TP 1(battery output)	Awa ½ hour 1 hour	VDC VDC VDC	6-8	11.98	0	Normal
2	Voltage Stabilizer Circuit	TP 2 (Step-down Module Input)		VDC	3-30	12 V	0	Normal
		TP 3 (ESP32 Input)		VDC	4.8-5.5	5.06	0	Normal
3	MQ Sensor	TP 4		VDC	0-5.5	3.956	0	Normal
4	Sensor Ultrasonic	TP 5		VDC	3-5.5	4.956	0	Normal
5	Sensor INA219	TP 6		VDC	0-5.5	3.956	0	Normal
6	LCD 16x2	TP 7		VDC	4.8-5	4.956	0	Normal
7	LED	TP 8		VDC	4.8-5	3.282	0	Normal

Ultrasonic sensor testing conducted to detect objects to be measured. Testing conducted 10 times from a value of 0 cm to more than 20 cm.

Table 3. Ultrasonic Sensor Testing

No	Measured Distance (cm)	Detected
1	0	Yes
2	2-4	Yes
3	4-6	Yes
4	6-8	Yes
5	8-10	Yes
6	10-12	Yes
7	12-14	Yes
8	14-16	Yes
9	16-20	Yes
11	>20	No

The INA219 sensor was tested 10 times. The purpose of this test was to examine the performance of the INA219 sensor in detecting battery voltage in the range of 0V to 7.5V. In addition, this test also aimed to convert the voltage to a battery percentage from 0% to 100%.

Table 4. INA219 Sensor Testing

No	Measured Voltage Measured (V)	Percentage Battery (%)	Description
1	4	53.33	Needs to be charged
2	4.25	56.67	Needs charging
3	4.5	60	Needs charging
4	5	66.67	Needs to be charged
5	5.5	73.33	Needs to be charged
6	6	80	Normal
7	6.5	86.67	Normal
8	7	93.33	Normal
9	7.25	96.67	Normal
11	7.5	100	Normal

Testing for preservatives or borax was conducted on eight types of food and beverage samples. The purpose of this testing was to determine the presence or absence of borax in each sample and the percentage of borax content if detected. In addition, this testing also aimed to ensure the safety of the samples based on applicable health standards. The test results are expected to provide an overview of the use of borax in the tested food and beverage products

Table 5 Preservative Detection Testing in Food and Beverages

No	Sample	Percentage Borax (%)	PPM (ppm)	Description
1	Tofu	0	0	Safe for consumption
2	Meatballs	5	0.88	Safe for consumption
3	Tempe	1	0.17	Safe for consumption
4	Ale-Ale	0	0	Safe for consumption
5	Tea Leaves	0	0	Safe for consumption
6	Seblak	18	3	Safe for consumption
7	White rice	0	0	Safe for consumption
8	Chicken	0	0	Safe for consumption

Based on the measurements and calculations performed, the following analysis can be made:

1. Based on the measurements conducted in Table 1 and Table 4.2, all measurement results are within the normal range according to the datasheet specifications for each component. The average voltage at each measurement point shows stable and consistent values, with a measurement error of 0%, which means that the device works well and accurately. This proves that the system is capable of regulating and distributing voltage according to the needs of each component, such as the stepdown module, ESP32, MQ sensor, ultrasonic sensor, INA219 sensor, 16x2 LCD, and LED.
2. Based on 10 ultrasonic sensor tests conducted to detect objects at distances ranging from 0 cm to more than 20 cm, the test results show that the sensor is capable of accurately detecting objects within a range of 0-20 cm. All distances within this range were detected properly, while at distances greater than 20 cm, the sensor no longer detected objects, in accordance with the sensor's capabilities.
3. The INA219 sensor is capable of providing accurate and consistent voltage data. The measured voltage is proportional to the battery percentage, where a voltage lower than 6V indicates that the battery needs to be recharged. A voltage of 6V and above indicates that the battery is in normal condition and ready for use, with the battery percentage increasing to 100% at a voltage of 7.5V.
4. Preservative or borax content testing was conducted on 8 types of food and beverage samples to detect the presence and percentage of borax. The test results showed that three samples, namely meatballs (20%), seblak (80%), and chicken meat (40%), tested positive for boric acid with significant percentages, while the other five samples were declared negative.

IV. CONCLUSION

Based on the results and discussion of the study "Monitoring of Preservative Detection Devices in Market Food Snacks," the following conclusions can be drawn. All measurement results in Table 4.1 and Table 4.2 show stable and consistent voltage in accordance with the datasheet specifications, with a measurement error of 0%, indicating that the system is working properly and accurately. The ultrasonic sensor accurately detects objects at a distance of 0-20 cm, while the INA219 sensor provides accurate and consistent voltage data, with voltages below 6V indicating that the battery needs to be recharged, and voltages above 6V indicating that the battery is in normal condition. Testing for boric acid content in 8 food and beverage samples showed that three samples—meatballs (20%), seblak (80%), and chicken meat (40%)— tested positive for boric acid, while the other five samples tested negative.

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