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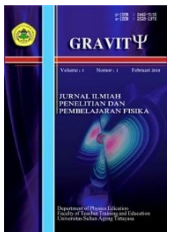

Development of formaldehyde detector in salted-fish using color sensor

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ABSTRACT

Currently, almost all traders use dangerous preservatives in salted fish, one of which is formaldehyde. Traders use these chemicals to make food more durable, even though the food will be consumed by humans. This is due to a lack of knowledge about foods that contain dangerous chemicals. Therefore, the Arduino Uno R3-based tool was developed. This Arduino Uno R3-microcontroller tool can test food practically and effectively quantitatively because it does not take long to see results. The TCS3200 was color sensor is used to detect food samples containing formaldehyde after being mixed with Formaldehyde Main Reagent according to the dosage. The sensor detects the changing color after everything has reacted, and a buzzer alarm will sound when the salted fish has formaldehyde. The test results are displayed on the 16x2 LCD screen and the NetBeans java application, where the output is a detection of whether salted fish has formalin or is formalin free. The initial data collection used a literature study and observation. This study used quantitative analysis and qualitative analysis. Based on the results, the performance test data of Formaldehyde Detector Prototype in Salted Fish Using Arduino Microcontroller-Based TCS3200 Color Sensor obtained a score of 74 or in the "Very Feasible" category.

Keywords : Arduino Uno R3, Buzzer, Formaldehyde, Java NetBeans, 16x2 LCD, TCS3200 Color Sensor

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INTRODUCTION

Formaldehyde is a poisonous substance and harmful to human health. If the body has a high formaldehyde content, it will react chemically with almost all substances in cells, suppress cell function, and cause cell death, causing poisoning in the body. In addition, the high formaldehyde content in the human body can also cause stomach irritation, allergies, carcinogenic or can cause cancer and mutagens or cause changes in cell or tissue function. People who take formaldehyde will vomit, have bloody diarrhea, bloody urine, and

even death due to circulatory failure. Formaldehyde can also evaporate in the air, as a colorless gas, with a pungent and suffocating odor that stimulates the nose, throat, and eyes. (Cahyadi, 2006).

The use of formaldehyde in salted fish is intended as a preservative, in addition to that, it is also intended to prevent fungal growth in salted fish and to increase the yield of salted fish. Salted fish with formaldehyde can then be seen by looking at the physical form of salted fish, where the salted fish with formaldehyde will have the following characteristics: the meat is more chewy, fuller, whiter and cleaner when compared to salted fish without Formaldehyde which tends to be darker in color and brownish. In addition, salted fish with Formaldehyde will not spoil for more than 1 month when stored at 25 C, does not emit the distinctive odor of salted fish, and does not get infested by flies when it is outdoors.

In 2010 BPOM (National Agency of Drug and Food Control of the Republic of Indonesia) discovered salted fish with formaldehyde in the Serang City area. Salted fish with formaldehyde was discovered at Rau Central Market on August 20, 2010. According to the BPOM Serang officer, Agustiawan, salted fish was found to contain formaldehyde after being examined in a mini-laboratory on the BPOM mobile car. Besides salted fish, traders sold the salted squid with formaldehyde. The discovery of salted fish with formaldehyde made residents around Rau Central Market afraid and hesitant to consume salted fish sold in that market. But in 2019, Serang City Health Office discovered dangerous food while inspecting food at Taman Sari Market, Serang City. Several foods were identified to contain textile dyes and chemical preservatives such as formaldehyde.

Salted fish with and without formaldehyde can be distinguished both from the naked eye and from the frying process, where salted fish with formaldehyde has a tougher texture than common salted fish, where the stomach is hard as a rock and difficult to cut, whereas salted fish without formaldehyde has a stomach that remains flabby and tender as well as easy to cut. In addition, when salted fish with formaldehyde is fried, it will curve while healthy salted fish or without formaldehyde will remain straight or flat like the initial shape before frying. All of these things can cause poisoning and other disorders.

Performance Test of the "Digital Formaldehyde Meter" as Formaldehyde Detector in Food had been conducted by Famelian Regeista in 2014. The purpose of the study was to create a "Digital Formaldehyde Meter" using Electronic Nose technology which is an alternative to formaldehyde detector. This tool was developed with a digital system, where the input signal is detected from the TGS sensor array (TGS 2600 and 2611) then processed with the help of a microcontroller which is amplified by a pre-amplifier and digitized by a formaldehyde content value can be generated. The main output of the study was only on the LCD which is not available in Java applications that can store data.

A study on formaldehyde detector in salted fish with the color sensor with the help of FMR (Formaldehyde Main Reagent) had been conducted by Hariyadi Singgih in 2013. The purpose of the study was to test the formaldehyde content in food ingredients, especially salted fish, using an automatic color sensor. This study was started by making a sample of formaldehyde solutions according to the calculated value as reference data. 2-3 ml Formaldehyde Main Reagent was added to the sample to make sample color. Color reading of the sample used the TCS3200 sensor. The main output of the study was only on the LCD which is not available in Java applications that can store data.

A study on Formaldehyde Detector Prototype Using Atmega8 Microcontroller-Based Grove HCHO had been conducted by S, Agnesia Trivani in 2018. The formaldehyde detector system was developed using the HCHO sensor to detect formaldehyde content in objects with the ATMega8 microcontroller to control the process where the reading was displayed on LCD and Buzzer as a warning that the object contains formaldehyde. This study only used buzzer and LCD as output.

Based on these problems, this study was limited to the development of a formaldehyde

detector with TCS3200 color sensor which can detect color changes using the help of FMR (Formaldehyde Main Reagent) which has an output in the form of LCD, buzzer and print out using a Java application that is connected directly between the test equipment and Java application.

METHOD

Development of Formaldehyde Detector Prototype in Salted Fish Using Arduino Microcontroller-Based TCS3200 Color Sensor The formaldehyde detector consists of several components, namely Arduino Uno R3 microcontroller, TCS3200 color sensor, Buzzer, 16x2 LCD, and Java application.

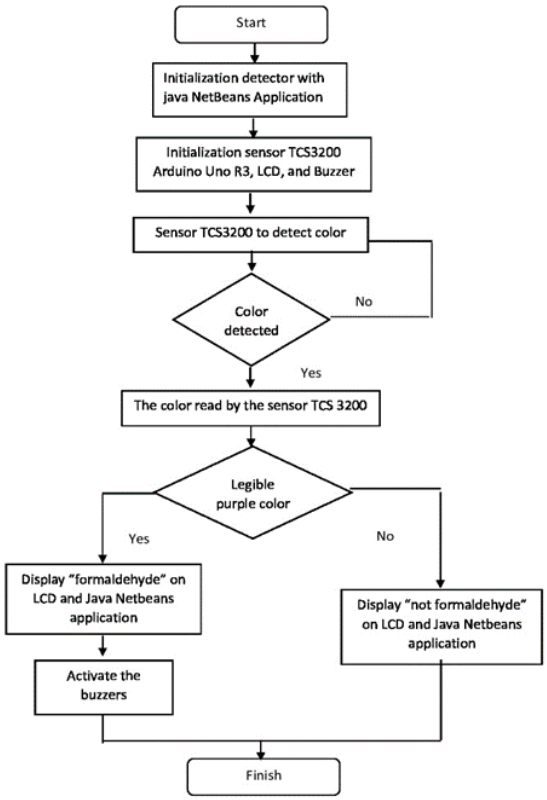

Figure 1. Block Diagram of Hardware and Software Design

B. Tool and Material Design

The formaldehyde detector system in salted fish used an open-loop control system because the output does not affect the input. The input is in the form of color from food samples that have been read by the TCS3200 color sensor and in the form of digital data that will be processed by Arduino Uno. The output is in the form of text and display in Java application or sound from buzzer based on the identified sample. The formaldehyde detector block diagram can be seen in the figure below.

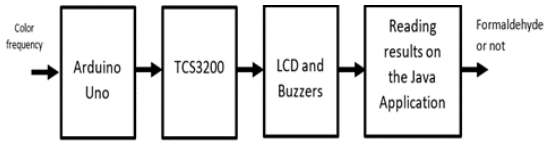

Figure 2. Flow Diagram

This tool was developed to identify formaldehyde using the TCS3200 color sensor. The TCS3200 color sensor works in increments to detect the fundamental color frequency simultaneously.

The system works starting from the initialization of the tool with the Java NetBeans application, after that, the color frequency reading by the TCS3200 color sensor. The color frequency read by the color sensor will be processed by Arduino as a controller. If it detects purple, Arduino displays that "the food contains formaldehyde" and displays the result on the 16x2 LCD and activates the buzzer, then displays automatically on the Java NetBeans application. Conversely, if the detected color is other than purple, then Arduino will display that the food is formaldehyde-free and the Java NetBeans application displays "formaldehyde-free".

The color is a mixture of the object (the food to be tested) and the Formaldehyde Main Reagent (FMR). This study measured the adapter output voltage, the RGB values of the TCS3200 color sensor output, and the tool as a whole. After testing and measurement, data analysis was conducted. The last stage was the design and manufacture of the casing and the layout of the circuit position as well as the reading sensor on the casing so that it looks tidier and minimalist and also the design of the Java NetBeans application as a storage medium using an excel database as output.

C. Hardware Design

In hardware design, hardware used were Arduino Uno R3, TCS3200 color sensor, Liquid Crystal Display (LCD), and Buzzer as

the indicator.

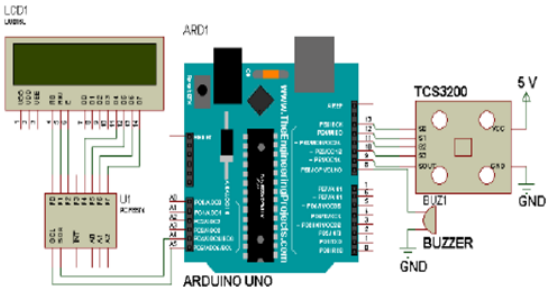

Figure 3. Formaldehyde Detector hardware design

D. Formaldehyde Detector Hardware Design

This study used Box Project Black X6 with a size of 18.5 cm x 11.5 cm x 6.5 cm with a sticker to tidy up the Project X6 box

Figure 4. project X6 Box

The box cover has a design to tell the position of the LCD components and the test tube holes as well as the formaldehyde content. The top and bottom design views can be seen in the following figure.

(a) (b)

Figure 5. Design of top view（a) and bottom view（b) on Project X6 Box

The box side has a design to tell the buzzer position and the name of the formaldehyde detector.

(a)

(b)

Figure 6. Desain of left view (a) and right view (b)

On the top and bottom side of the box, there are only “USB Port” and “Power Switch”.

(a) (b)

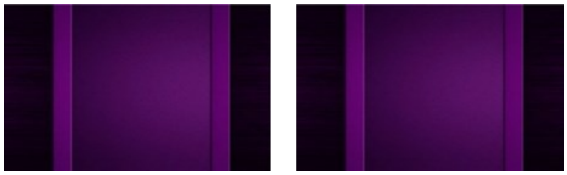

Figure 7. Desain of top side (a) and bottom side (b)

E. Software Design

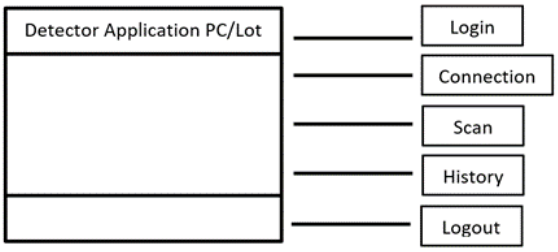

Figure 8. Use Case Diagram

Use case diagram functions to describe the menu facilities provided to the user. Users are people who are entitled to use an application, while use cases are techniques used in developing a software or information system to meet the functional requirements of the system. The use case describes the system, the environment in the system, and the relationship between the system and its environment.

F. Java Net Beans Interface of Formaldehyde Detector

Interface design is the most important part of designing a system. The goal of interface design is to make user interaction with the computer as simple and efficient as possible. Here is a mock-up view of the formaldehyde detector main interface.

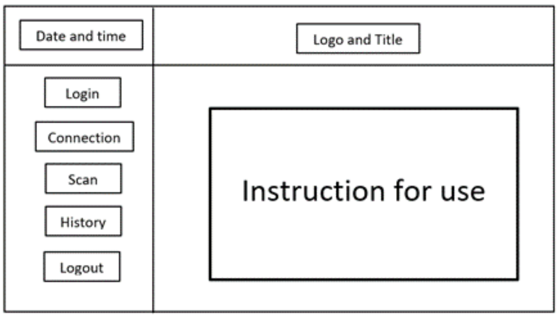

Figure 9. Formaldehyde Detector Main Interface

RESULT AND DISCUSSION

A. TCS3200 color sensor test

The purpose of this test was to see the RGB value of each food sample as measured by the TCS3200 color sensor. RGB is the value of the frequency of red, green, and blue. The amount of the RGB value measured on one object is different from the RGB value measured on another object. This value can be affected by light intensity.

The TCS3200 color sensor test was carried out to determine the condition of the system and program. The test was carried out to obtain the RGB reference value of each formaldehyde sample color. The reference from the RGB value was used as a reference in the Arduino program in filtering the formaldehyde sample colors. The tool developed must be able to work well.

The TCS3200 color sensor detected the color of the salted fish sample. The results of the RGB value measurement for each food sample will be displayed on the Arduino IDE monitor serial display using a laptop (notebook).

Table 1. RGB Measurement by TCS3200 color sensor in 3 Types of Salted Fish with Formaldehyde

Layur Fish Salt			Layur Fish Salt			Layur Fish Salt		
R	G	B	R	G	B	R	G	B
132	300	107	144	259	126	125	165	100
132	300	107	144	259	126	125	165	100
132	300	107	144	259	126	125	165	100
132	300	107	144	259	126	125	165	100
132	300	107	144	259	126	125	165	100
132	300	107	144	259	126	125	165	100
132	300	107	144	259	126	125	165	100
132	300	107	144	259	126	125	165	100
132	300	107	144	259	126	125	165	100
132	300	107	144	259	126	125	165	100

Table 1 shows the test results on 3 types of salted fish (Layur, Peda, Temburu) with formaldehyde. Table 1 shows the change in numbers for each sample. The R frequency values of the three types of salted fish were 132, 144, 125. The G frequency values of the three types of salted fish were 300, 259, 165. The B frequency values of the three types of salted fish were 107, 126, 100. Each value of R, G, and B were different but still close to each other. The difference in RGB values for each type of salted fish can be caused by the light intensity that was exposed to the TCS3200 color sensor and the object (salted fish with formaldehyde). In addition, the placement of the test tube between the TCS3200 color sensor and the object (formaldehyde drop sample) also had an influence on the measured RGB value. The farther the TCS3200 color sensor and sample are, the higher or lower the RGB value will be.

B. RGB Measurment Results in 10 Layur Salted Fish with Formaldehyde + without Formaldehyde

Table 2. RGB Measurement Results in 10 Layur Salted Fish with and without Formaldehyde

No.	Sample	RGB Value R	G	B	RESULTS
1	Layur Salted Fish 1	118	245	88	Formaldehyde
2	Layur Salted Fish 2	132	300	97	Formaldehyde
3	Layur Salted Fish 3	128	293	96	Formaldehyde
4	Layur Salted Fish 4	119	246	88	Formaldehyde
5	Layur Salted Fish 5	128	245	88	Formaldehyde
6	Layur Salted Fish 6	265	430	361	Without Formaldehyde

No.	Sample	RGB Value R	G	B	RE-SULTS
7	Layur Salted Fish 7	255	433	373	Without Formal-dehyde
8	Layur Salted Fish 8	263	423	351	Without Formal-dehyde
9	Layur Salted Fish 9	275	423	354	Without Formal-dehyde
10	Layur Salted Fish 10	273	423	368	Without Formal-dehyde

Table 2 shows the RGB measurement of the 10 Layur Salted Fish. The R frequency values were 118, 132, 128, 119, 128 for salted fish with formaldehyde and 265, 255, 263, 275, 273 for salted fish without formaldehyde. The G frequency values were 245, 300, 293, 246, 245 for salted fish with formaldehyde and 430,433,423,423,423 for salted fish without formaldehyde. The B frequency values were 88, 97, 96, 88, 88 for salted fish with formaldehyde and 361, 373, 351, 354, 368 for salted fish without formaldehyde. From the measurement results, the test results tended to be close, some RGB values differed between salted fish with formaldehyde and without formaldehyde, and but there were also the same. The difference in RGB values for each sample of salted fish with and without formaldehyde can be caused by the light intensity that was exposed to the TCS3200 color sensor and the object (layur salted fish with and without formaldehyde). In addition, the placement of the test tube between the TCS3200 color sensor and the object (layur salted fish with and without formaldehyde) also had an influence on the measured RGB value. The farther the TCS3200 color sensor and sample are, the higher or lower the RGB value will be.

C. RGB Measurement Results in 10 Peda Salted Fish with Formaldehyde + without Formaldehyde

Table 3. RGB Measurement Results in 10 Peda Salted Fish with and without Formaldehyde

No.	Sample	RGB Value R	G	B	RE-SULTS
1	Peda Salted Fish 1	144	159	126	Formal-dehyde
2	Peda Salted Fish 2	111	163	104	Formal-dehyde
3	Peda Salted Fish 3	121	193	116	Formal-dehyde
4	Peda Salted Fish 4	132	170	101	Formal-dehyde
5	Peda Salted Fish 5	138	192	102	Formal-dehyde
6	Peda Salted Fish 6	265	423	371	Without Formal-dehyde
7	Peda Salted Fish 7	272	417	364	Without Formal-dehyde
8	Peda Salted Fish 8	273	424	367	Without Formal-dehyde
9	Peda Salted Fish 9	263	422	367	Without Formal-dehyde
10	Peda Salted Fish 10	270	416	364	Without Formal-dehyde

Table 3 shows the RGB measurement of the 10 Peda Salted Fish. The R frequency values were 144, 111, 121, 132, 138 for salted fish with formaldehyde and 265, 272, 273, 263, 270 for salted fish without formaldehyde. The G frequency values were 159, 163, 193, 170, 192 for salted fish with formaldehyde and 423,417,424,422,416 for salted fish without formaldehyde. The B frequency values were 126, 104, 116, 101, 102 for salted fish with formaldehyde and 371, 364, 367, 367, 364 for salted fish without formaldehyde. From the measurement results, the test results tended to be close, some RGB values differed between salted fish with formaldehyde and without formaldehyde, and but there were also the same. The difference in RGB values for each sample of salted fish with and without formaldehyde can be caused by the light intensity that was exposed to the TCS3200 color sensor and the object (peda salted fish with and without formaldehyde). In addition, the placement of the test tube between the TCS3200 color sensor and the

object (peda salted fish with and without formaldehyde) also had an influence on the measured RGB value. The farther the TCS3200 color sensor and sample are, the higher or lower the RGB value will be.

D. RGB Measurement Results in 10 Temburu Salted Fish with Formaldehyde + without Formaldehyde

Table 4. RGB Measurement Results in 10 Temburu Salted Fish with Formaldehyde + without Formaldehyde

No.	Sample	RGB Value			RESULTS
		R	G	B	
1	Temburu Salted Fish 1	146	205	123	Formaldehyde
2	Temburu Salted Fish 2	125	195	110	Formaldehyde
3	Temburu Salted Fish 3	110	193	116	Formaldehyde
4	Temburu Salted Fish 4	131	200	111	Formaldehyde
5	Temburu Salted Fish 5	137	194	118	Formaldehyde
6	Temburu Salted Fish 6	263	423	374	Without Formaldehyde
7	Temburu Salted Fish 7	268	410	361	Without Formaldehyde
8	Temburu Salted Fish 8	271	422	365	Without Formaldehyde
9	Temburu Salted Fish 9	271	416	365	Without Formaldehyde
10	Temburu Salted Fish 10	270	416	364	Without Formaldehyde

Table 4 shows the RGB measurement of the 10 Temburu Salted Fish. The R frequency values were R 146, 125, 110, 131, 137 for salted fish with formaldehyde and 263, 268, 271, 271, 270 for salted fish without formaldehyde. The G frequency values were 205, 195, 193, 2000, 194 for salted fish with formaldehyde and 423,410,422,416,416 for salted fish without formaldehyde. The B frequency values were 123, 110, 116, 111, 118 for salted fish with formaldehyde and 374, 361, 365, 365, 364 for salted fish without formaldehyde. From the measurement results, the test results tended to be close, some RGB values differed between salted fish with formaldehyde and without formaldehyde, and but there were also the same. The difference in RGB values for each sample of salted fish with and without formaldehyde can be caused by the light intensity that was exposed to the TCS3200 color sensor and the object (Temburu salted fish with and without formaldehyde). In addition, the placement of the test tube between the TCS3200 color sensor and the object (Temburu salted fish with and without formaldehyde) also had an influence on the measured RGB value. The farther the TCS3200 color sensor and sample are, the higher or lower the RGB value will be.

E. Sensor Reading Time in 10 Layur salted fish with Formaldehyde + Without Formaldehyde.

Table 5. Sensor Reading Time in 10 Layur salted fish with Formaldehyde and Without Formaldehyde

No.	Sample	Sensor Reading Time	Results
1	Layur Salted Fish 1	0.46 second	Formaldehyde
2	Layur Salted Fish 2	0.23 second	Formaldehyde
3	Layur Salted Fish 3	0.92 second	Formaldehyde
4	Layur Salted Fish 4	1.15 second	Formaldehyde
5	Layur Salted Fish 5	2.34 second	Formaldehyde
6	Layur Salted Fish 6	0. 10 second	Without Formaldehyde
7	Layur Salted Fish 7	0. 10 second	Without Formaldehyde
8	Layur Salted Fish 8	0. 10 second	Without Formaldehyde

No.	Sample	Sensor Reading Time	Results
9	Layur Salted Fish 9	0. 10 second	Without Formaldehyde
10	Layur Salted Fish 10	0. 10 second	Without Formaldehyde

Table 5 shows the TCS3200 color sensor reading time in 10 Layur Salted Fish. The range of sensor reading time was between 0.46 second to 2.34 seconds with an average of 1.02 second for salted fish with formaldehyde and 0.10 second for salted fish without formaldehyde. From the measurement results, the test results tended to be close due to light intensity that was exposed to the TCS3200 color sensor and the object (Layur salted fish with Formaldehyde). In addition, the placement of the test tube between the TCS3200 color sensor and the object (Layur salted fish with Formaldehyde) also had an influence on the sensor reading time. The farther the TCS3200 color sensor and sample are, the higher or lower the measured reading time will be. The average sensor reading time was 0.10 seconds for salted fish without formaldehyde due to the sensor continues to read the value of the salted fish without formaldehyde so that if there is salted fish without formaldehyde, the tool will automatically detect the salted fish without formaldehyde.

F. sensor Reading Time in 10 Peda salted fish with Formaldehyde + Without Formaldehyde

Table 6. Sensor Reading Time in 10 Peda salted fish with Formaldehyde and Without Formaldehyde

No.	Sample	Sensor Reading Time	Results
1	Peda Salted Fish 1	2.33 second	Formaldehyde
2	Peda Salted Fish 2	1.24 second	Formaldehyde
3	Peda Salted Fish 3	2.46 second	Formaldehyde
4	Peda Salted Fish 4	3.98 second	Formaldehyde
5	Peda Salted Fish 5	4.20 second	Formaldehyde
6	Peda Salted Fish 6	0. 10 second	Without Formaldehyde
7	Peda Salted Fish 7	0. 10 second	Without Formaldehyde
8	Peda Salted Fish 8	0. 10 second	Without Formaldehyde
9	Peda Salted Fish 9	0. 10 second	Without Formaldehyde
10	Peda Salted Fish 10	0. 10 second	Without Formaldehyde

Table 6 shows the TCS3200 color sensor reading time in 10 Peda Salted Fish. The range of sensor reading time was between 1.24 second to 4.20 seconds with an average of 2.84 second for salted fish with formaldehyde and 0.10 second for salted fish without formaldehyde. From the measurement results, the test results tended to be close due to light intensity that was exposed to the TCS3200 color sensor and the object (peda salted fish with formaldehyde). In addition, the placement of the test tube between the TCS3200 color sensor and the object (peda salted fish with formaldehyde) also had an influence on the sensor reading time. The farther the TCS3200 color sensor and sample are, the higher or lower the measured reading time will be. The average sensor reading time was 0.10 seconds for salted fish without formaldehyde due to the sensor continues to read the value of the salted fish without formaldehyde so that if there is salted fish without formaldehyde, the tool will automatically detect the salted fish without formaldehyde.

G. Sensor Reading Time in 10 Temburu salted fish with Formaldehyde + Without Formaldehyde

Table 7. Sensor Reading Time in 10 Temburu salted fish with Formaldehyde + Without Formaldehyde

No.	Sample	Sensor Reading Time	RESULTS
1	Temburu Salted Fish 1	3.01 second	Formaldehyde
2	Temburu Salted Fish 2	1.05 second	Formaldehyde
3	Temburu Salted Fish 3	0.73 second	Formaldehyde
4	Temburu Salted Fish 4	0.97 second	Formaldehyde
5	Temburu Salted Fish 5	1.38 second	Formaldehyde
6	Temburu Salted Fish 6	0. 10 second	Without Formaldehyde
7	Temburu Salted Fish 7	0. 10 second	Without Formaldehyde
8	Temburu Salted Fish 8	0. 10 second	Without Formaldehyde
9	Temburu Salted Fish 9	0. 10 second	Without Formaldehyde
10	Temburu Salted Fish 10	0. 10 second	Without Formaldehyde

Table 7 shows the TCS3200 color sensor reading time in 10 Temburu Salted Fish. The range of sensor reading time was between 0.73 second to 3.01 seconds with an average of 1.42 second for salted fish with formaldehyde and 0.10 second for salted fish without formaldehyde. From the measurement results, the test results tended to be close due to light intensity that was exposed to the TCS3200 color sensor and the object (Temburu salted fish with formaldehyde). In addition, the placement of the test tube between the TCS3200 color sensor and the object (Temburu salted fish with formaldehyde) also had an influence on the sensor reading time. The farther the TCS3200 color sensor and sample are, the higher or lower the measured reading time will be. The average sensor reading time was 0.10 seconds for salted fish without formaldehyde due to the sensor continues to read the value of the salted fish without formaldehyde so that if there is salted fish without formaldehyde, the tool will automatically detect the salted fish without formaldehyde.

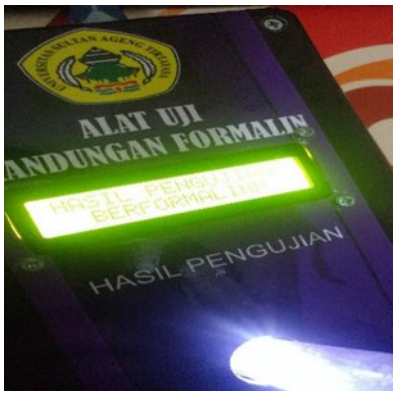

Figure 10. Test Results on Formaldehyde Content Test Equipment

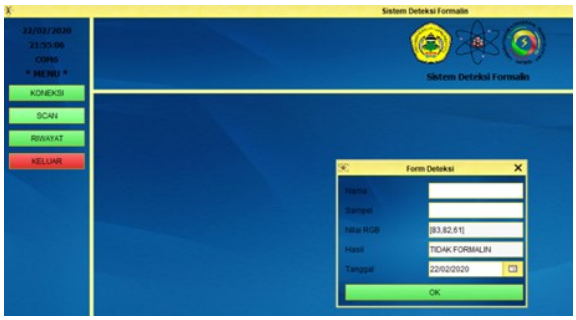

Figure 11. Formaldehyde Detector Application Testing Result

CONCLUSION

Based on the test on Arduino Uno R3-based TCS3200 color sensor as formaldehyde detector, it can be concluded that:

1. The formaldehyde detector in salted fish was successfully developed using Arduino Uno R3 as the main controller and the Java NetBeans application as print output.
2. The formaldehyde detector has a color sensor input response that varies according to the food color conditions read by the TCS3200 color sensor from each sample.
3. The formaldehyde detector will be more effective at reading data if the instrument is placed in a dark place or in the task arena because the TCS3200 color sensor is very sensitive to the influence of light intensity.
4. The sensor will read the color stable if the color sensor condition is attached to the food sample.
5. The measurement results of salted fish

with formaldehyde can be read and displayed on 16x2 LCD and NetBeans Java application.

6. The formaldehyde detector has worked well based on the results of Chapter 4. Layur Salted Fish, Peda Salted Fish, and Temburu Salted Fish had different color accuracy.
7. The distance between the test tube object and the TCS3200 color sensor greatly affects the reading.

REFERENCES

Adawyah, R. (2007). *Pengolahan dan Pengawetan Ikan*. Jakarta: Bumi Aksara.

Afrianto, E., & Liviawaty, E. (1989). *Pengawetan dan Pengolahan Ikan.* Yogyakarta: Kanisius.

Alsuhendra, & Ridawati. (2013). *Bahan Toksik dalam Makanan.* Bandung: PT. Remaja Rosdakarya.

Astawan, M. (2006). *Mengenal Formalin dan Bahayanya*. Jakarta: Penebar Swadaya.

Branch, R. M. (2009). *Instructional Design : The ADDIE Approach.* Springer: New York.

Cahyadi, W. (2006). *Analisis & Aspek Kesehatan Bahan Tambahan Makanan.* Jakarta: Bumi Aksara.

Departemen Kesehatan Republik Indonesia. Peraturan Menteri Kesehatan (Menkes) RI No. 33 Tahun 2012

Departemen Kesehatan Republik Indonesia. Peraturan Menteri Kesehatan Republik Indonesia Nomor 1168/MENKES/PER/X/1999

Departemen Kesehatan Republik Indonesia. Peraturan Menteri Kesehatan RI No. 722/Men.Kes/Per/IX/88 Tentang Bahan Tambahan Makanan

Gridling, G., & B, W. (2007). *Introduction to Microcontrollers.* Vienna: University of Technology Institute of Computer Engineering Embedded Computing Systems Group.

Islahudin. (2018). *Buku Ajar Dasar-Dasar Elektronika Analog, Digital dan Sensor.* Yogyakarta: Deepublish.

Mahdi, C dan Mubarrak, Shofi A. 2008. Uji Kandungan Formalin, Borak dan Pewarna Rhodamin pada Produk Perikanan dengan Metode Spot Test. Berkala Ilmiah Perikanan Vol.3, Universitas Brawijaya.

Meutuah, Mahfud. 2011. Perbandingan Metode Deteksi Formalin Secara Kualitatif Menggunakan Asam Kromatofat dan Kit Test. https://kuliah-bhn.blogspot.com/2011/06/perbandingan-metode-deteksi-formalin.html. Diakses Tanggal 30 Agustus 2019

National Cancer Institute. 2009. ***Formaldehyde and Cancer Risk***. https://www.cancer.gov/about-cancer/causesprevention/risk/substances/formaldehyde/formaldehyde-fact-sheet. Diakses : 30 Agustus 2019

Peraturan Pemerintah Republik Indonesia Nomor 28 Tahun 2004 Tentang Keamanan, Mutu dan Gizi Pangan

Ralp, F. J., & Joan, F. S. (1986). *Kimia Organik.* Jakarta: Erlangga.

Regeista, F. (2014). Uji Performansi Alat "Digital Formaldehyde Meter" Pendeteksi Kandungan Formalin pada Makanan. *Jurnal Keteknikan Pertanian Tropis dan Biosistem*, 97 - 103

Singgih, H. (2013). Uji kandungan formalin pada ikan asin menggunakan sensor warna dengan bantuan FMR (Formalin Main Reagent). *J. ELTEK*, 55-70.

Sobari, E. (2016). *Panduan Teknik Pengolahan dan Pengawetan Pangan.* Yogyakarta: Deepublish.

Sugiyono. (2014). *Metode Penelitian Kuantitatif, Kualitatif dan R&D Jilid 2*. Bandung: Alfabeta.

Sugiyono. (2017). *Metode Penelitian Kuantitatif, Kualitatif dan R&D Jilid 3*. Bandung: Alfabeta.

Susanto, I. (2018). *Microcontroller : Menguasai Arduino.* Yogyakarta: Teknosain.

Sutrisno, H. (2004). *Metodologi Research Jilid 2*. Yogyakarta: ANDI.

Syahwil, M. (2013). *Panduan Mudah Simulasi dan Praktik Miktronkontroler Arduino*. Yogyakarta: ANDI.

Wasito, S. (2004). *Data Sheet Book 1 Data IC Linier, TTL dan CMOS*. Jakarta: PT. Elex Media Komputindo.

WHO. (2002). *Suhu Formaldehid Terdekomposisi.* Jakarta: Indonesia.

Yuliarti, N. (2007). *Awas ! Bahaya di Balik Lezatnya Makanan.* Yogyakarta: ANDI..