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Web-Based Formaldehdyde Detection System in Chickens using Iot and Fuzzy Logic

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Abstract

Chicken is a widely consumed source of animal protein globally. Ensuring the freshness of chicken meat is essential to guarantee its health and prevent harm to consumers. Unfortunately, there are concerns about the use of harmful substances such as formalin used by some traders to preserve their meat. Formalin, a clear liquid with a very pungent odor, is commonly used as a food preservative. To overcome the abuse of formalin in broiler chickens, an innovative IOT and Fuzzy Logic Technology was created to detect food ingredients. The formalin detection system developed uses an ESP8266 microcontroller and a TCS3200 color sensor to assess color variations in chicken meat samples mixed with Schiff reagent. The TCS3200 sensor detects color changes, and the ESP8266 Microcontroller converts the measurements into RGB base colors. Calibration of the sensor resulted in a relative accuracy of 98.30% at a distance of 3 cm. Fuzzy logic is then applied to determine the formaldehyde level, which is displayed on the LCD screen. The device showed a reliability of 95% to achieve a level of 0 ppm, 93% for 40 ppm, 92% for 80 ppm, and 100% for 200 ppm.

Keywords: esp8266, Formalin, IoT, TCS3200, Schiff reagent

I. INTRODUCTION

Food is a basic necessity for living beings, required for daily consumption to provide sustenance and energy. Therefore, all food to be consumed must be classified as healthy and free from harmful substances. In the current market scenario, there is a prevalent issue where many traders still use hazardous chemicals such as formalin to preserve the meat they sell. Formalin is a clear liquid with a strong and pungent odor, commonly used as a food preservative and a preservative in laboratories [1].

At present, many irresponsible traders or individuals exploit slaughtered chickens due to the increasing demand and rising prices. Sellers do not want to incur losses and only seek excessive profits. The danger of food preservatives such as formalin or other harmful preservatives entering the human body can cause digestive problems, poisoning, cancer, and even death. Physical characteristics of formalin-mixed chicken include changes in color and odor [2].

In response to cases of the misuse of the harmful substance formalin in slaughtered chickens, a solution is presented through a formalin detection device using IoT (Internet of Things) and TCS3200 sensor system, providing several benefits and solutions to address health-related issues.

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IoT is a concept where physical objects or devices aim to be widely and continuously connected to the internet and other physical objects using network sensors and actuators, with the goal of obtaining data and managing their own performance. This IoT system is presented through the ESP8266 communication module to facilitate users in viewing the acquired data. Fuzzy Logic is also employed in this system to obtain its RGB values. The digital evaluation obtained from this process represents the maximum and minimum values of the sensor output, which were predetermined during the sample creation and will be incorporated into its instrumentation program. The sensor output can be concluded based on the existence value in the predetermined conditions with the data available in the Fuzzy Logic method.

In previous research, the first author only provided a tool design that was less flexible when reading data where data could not be stored in real time and had to record data manually after testing. The second author uses the KNN method or the abbreviation for (K-Nearest Neighbor) which is the method the author uses is quite complicated to be used as my research method, therefore I use another method, namely the Fuzzy Logic method which is very simple to use by just setting a low limit. and high limits only. Therefore, from the 2 studies above, the author implemented IoT in real time and Fuzzy Logic as a formaldehyde detection tool which can make it easier during research to view data in real time or at any time so that later it will be followed up by authorized parties such as BPOM if it is detected. The presence of formaldehyde levels in broiler chickens will be tested so that consumers know where to sell healthy and fresh broiler chickens.

When detecting formalin levels in broiler chickens. when the concentration of formalin in food ingredients is determined in two stages. The first stage is to determine the formalin content in the sample being tested using Schiff's reagent. If the food ingredient or test sample changes color to pink or purple then the sample is declared positive for containing formaldehyde, a color change will occur. Then, in the second stage, color changes in the sample are detected by the TCS3200 sensor and based on the RGB values calibrated via the ESP8266. The ESP8266 calibration algorithm is designed to test chicken meat samples detecting formalin concentrations ranging from 0 ppm to 200 ppm.

II. RELATED STUDY

In previous research, the first author only provided a tool design that was less flexible when reading data where data could not be stored in real time and had to record data manually after testing. The second author uses the KNN method or the abbreviation for (K-Nearest Neighbor) which is the method the author uses is quite complicated to be used as my research method, therefore I use another method, namely the Fuzzy Logic method which is very simple to use by just setting a low limit. and high limits only. Therefore, from the 2 studies above, the author implemented IoT in real time and Fuzzy Logic as a formaldehyde detection tool which can make it easier during research to view data in real time or at any time so that later it will be followed up by authorized parties such as BPOM if it is detected. The presence of formaldehyde levels in broiler chickens will be tested so that consumers know where to sell healthy and fresh broiler chickens.

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III. RESEARCH METHOD

The research methodology for this final project has been carefully designed, covering different stages to ensure a systematic and thorough investigation. The initial stage involves an in-depth Literature Review, where information is extensively collected, analyzed, and synthesized from various written sources. This process aims to establish a solid understanding of existing knowledge and its relevance to the chosen topic or problem.

Then, this project adopts the Waterfall Method, a well-structured software development approach characterized by a linear and hierarchical progression of stages. In this method, each stage must be successfully completed before proceeding to the next stage. The Waterfall Method consists of a sequence of steps, including requirements gathering, system design, implementation, testing, deployment, and maintenance. This approach ensures a methodical and organized development process, allowing for clear delineation of tasks and dependencies between stages. The emphasis on completing each stage before moving on to the next will improve the overall efficiency and reliability of the project.

A. *Microcontroller ESP8266*

The ESP8266 is a microcontroller chip or module designed to facilitate the connection of electronic devices through Wi-Fi. This module possesses integrated microcontroller capabilities and can be utilized to embed Wi-Fi connectivity in various electronic applications. The ESP8266 is commonly employed in building IoT-based applications, such as controlling smart home devices and monitoring environmental conditions [4].

Fig. 1. Microcontroller ESP8266

B. *Sensor Color TCS3200*

The TCS3200 Color Sensor is an integrated circuit component capable of converting light colors into frequency values. This sensor exemplifies a device that utilizes the RGB color model to detect the color of an object. Equipped with features like infrared (IR), a power supply ranging from 3V to 5V, a serial interface 12C, and the ability to detect object colors in low-light conditions, the TCS3200 enhances color detection accuracy [3].

Fig. 2. Sensor Color TCS3200

C. *Fuzzy Logic Method*

Table I is the fuzzy logic data program input that has been obtained from this process, which involves determining the minimum and maximum values of the sensor output during sample generation, which are then entered into the instrumentation program. In *Table* II, these minimum and maximum values serve as sensor detection limits. The sensor output can be conclusively interpreted by assessing the presence value under the same conditions as the data in the fuzzy logic method. [5].

TABLE I
FUZZY LOGIC DATA ENTERED INTO THE PROGRAM

Fuzzy Logic	Red	Green	Blue
0 ppm	255 ≥ x ≥ 245	251 ≥ x ≥ 243	255 ≥ x ≥ 245
40 ppm	248 ≥ x ≥ 242	222 ≥ x ≥ 210	241 ≥ x ≥ 235
80 ppm	237 ≥ x ≥ 225	183 ≥ x ≥ 177	237 ≥ x ≥ 227
200 ppm	218 ≥ x ≥ 212	116 ≥ x ≥ 95	201 ≥ x ≥ 184

TABLE II
MAXIMUM AND MINIMUM VALUE DATA RED, GREEN, BLUE

Formalin Concentration (ppm)	***Red***		***Green***		***Blue***	
	max	***min***	***max***	***min***	***Max***	***min***
0 ppm	255	249	255	243	254	245
40 ppm	248	240	225	214	240	236
80 ppm	235	228	183	179	235	225
200 ppm	220	215	119	100	203	188

In Figure 3, one can see the color changes that occur from 0 ppm, 40 ppm, 80 ppm, and 200 ppm, where the higher the ppm, the darker the color of the sample. The difference in formalin content values is because the higher the ppm, the more formalin content drops. From the experiment, we get the max and min values which can be seen in Table II. This test has been carried out 10 times, data on the max and min RGB values at formalin levels of 0 ppm - 200 ppm. The higher the formalin content, the smaller the min max RGB value.

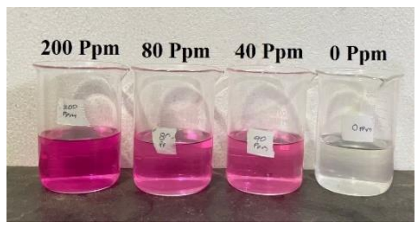

Fig. 3. Formalin Level Test Results

D. *Flowchart Design*

The program to be executed for data processing can be used to read the data from the sensor. Once activated, the system reads the data received by the TCS3200 Color Sensor in the form of colors. Next, the system checks and processes the received data. The processed data is then displayed on the LCD screen and stored on the web platform through the available internet connection [6]. This website includes information such as time (in minutes), RGB data, status, and description. The ESP8266 microcontroller checks the received formaldehyde level. If the formaldehyde level is negative, the obtained value is set to 0 ppm [7]. Conversely, if the formaldehyde level is positive, the obtained values are set to 40, 80, and 200 ppm.

E. *System Design*

1. *System Block Diagram*

The design and functionality is designed in accordance with existing references in IoT-based systems and formaldehyde detection methodologies. The integration of the TCS3200 Color Sensor and ESP8266 microcontroller for data processing conforms to recognized practices in sensor-based IoT applications [8]. The web-based storage and display of processed data reflects the prevalent approach for data visualization and accessibility in IoT frameworks. The categorization of formaldehyde levels, ranging from 0 ppm for negative readings to a specific value for positive readings, is consistent with the literature detailing the assessment of formaldehyde concentration in various detection systems. The System Block indicates the need for initial sample collection, where the object's test color is determined by the TCS3200 color sensor, which operates in a range of wavelengths, translating them into basic RGB colors. Next, the ESP8266 microcontroller processes the data obtained from the color sensor, which consists of RGB color data, and calibrates it into parts per million (ppm). The calibrated data is then displayed on the LCD and stored on the web server.

2. User Interface Design

The User Interface Design is a collaborative process involving designers, developers, and users. The overall objective of this process, as per referenced literature, is to create an intuitive, enjoyable, and efficient user experience. The interface design for the website in this system is intended to support multi-user functionality upon implementation. It includes a main page with data graphics, a data page, and a monitoring page presented in tabular form [9]. The web interface aims to facilitate user monitoring of formalin levels in tested chicken, aligning with the principles of user-friendly design emphasized in previous studies.

F. LCD Design

The creation of the LCD circuit design in Fig. 4 is crucial to obtaining the desired output from the sensor used. The LCD has four pins: GND, VCC, SDA, and SCL. Referring to the literature, Pin GND is connected to the negative pin on the breadboard, while Pin VCC is connected to the positive pin on the breadboard to receive power supply from the ESP. Pin SDA is routed to digital pin D2 on the ESP, and Pin SCL is also routed to digital pin D1.

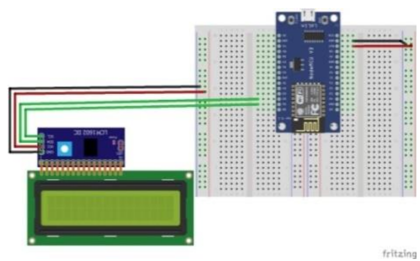

Fig. 4. LCD Design

G. ESP8266 Design

The ESP8266 module design in Fig. 5 aims to connect to available Wi-Fi signals and transmit data to a designated website for the final results. Although the module has multiple pins, the focus is on connecting the power pins, specifically GND (negative) and RST (positive) [10].

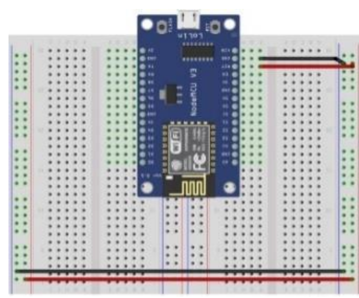

Fig. 5. ESP8266 Design

H. TCS3200 Sensor Design

The TCS3200 module design in Fig. 6 is utilized for color detection on its sensor. While there are 10 pins on the TCS3200, the author uses 7 pins for this design: GND, VCC, OUT, S0, S1, S2, and S3. GND is connected to the negative pin on the breadboard, and VCC is connected to the positive pin on the breadboard for power supply. OUT is linked to pin D6 on the TCS3200, S0 is connected to digital pin D7, S1 to digital pin D3, S2 to D4, and S3 is routed to digital pin D5.

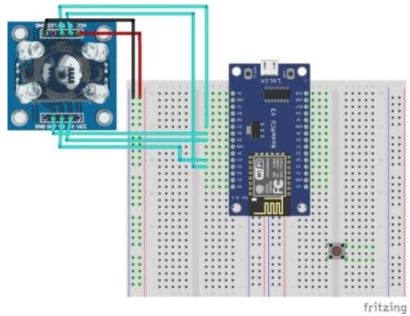

Fig. 6. TCS3200 Sensor Design

I. Wiring Formalin Level Detection Tool

The system design scheme in Fig. 7 comprises various components appropriately combined to ensure smooth operation. The wiring diagram illustrates the IoT and Fuzzy Logic-based Formalin Detection Device for Chicken using the TCS3200 color sensor, aligning with principles established in prior references.

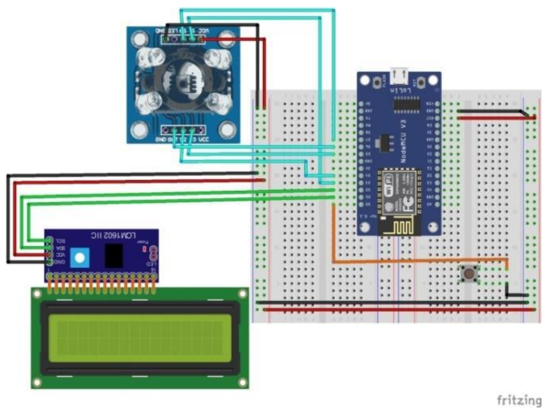

Fig. 7. Design of a Program for Detecting Formalin Levels in Chickens

J. Experimental Design

Experimental Design is a systematic process of planning and organizing a research experiment, which aims to test hypotheses or answer research questions in a structured manner. This is adjusted to the control variables that influence the observation results, thereby allowing researchers to draw accurate conclusions about the cause-and-effect relationship between the variables studied. The experimental design that the author made is to develop an IOT device to detect formaldehyde levels, namely by preparing a TCS3200 color sensor, 16x2 LCD, Breadboard and also jumper cables to connect to each other. Then how does the device connect to the internet? The author added 1 software, namely ESP8266, which can be integrated with the WiFi module at the same time so that the detection results can be displayed on the website and the detection data is stored on the available cloud server.

K. Sample Testing Scenario

The testing scenario for the IoT-based Formalin Detection Device using the TCS3200 Sensor begins with tool and material preparation. The integrated tool with the TCS3200 sensor is readied alongside formalin samples and Schiff's reagent as the concentration indicator [11]. The initial phase involves sensor calibration to ensure color measurement accuracy and adjustment of the sensor to known formalin concentration samples, with the author selecting a distance of 3 cm. Subsequently, the safe formalin threshold is determined, and direct measurements are taken by placing the sensor on each formalin sample. The sensor-generated color data is transmitted to the IoT platform for analysis. The use of algorithms or models on the IoT platform enables the identification of whether the formalin concentration in the sample exceeds the set threshold [12]. Detection results are then verified by comparing them with the actual concentration in each sample. The testing also involves analyzing the tool's performance under various environmental conditions and examining sample variations to validate result consistency. During long-term testing, the tool is monitored to ensure daily durability and reliability, and updates or further development are implemented as needed. Detailed documentation of testing results, including sensor parameters, data analysis, and implemented improvement or development steps, serves as the basis for the tool's user manual and maintenance guide. This experimental design aligns with established methodologies, ensuring the reliability and effectiveness of the IoT-based formalin detection instrument.

IV. RESULTS AND DISCUSSION

A. *Implementation of the Instument Design*

The implementation of the instrument design for formalin detection using Internet of Things (IoT) technology and Fuzzy Logic, utilizing the TCS3200 sensor, has been detailed. The instrument is meticulously designed with a casing made of black acrylic material, complemented by an LCD screen serving as an indicator. This design choice ensures the instrument's resilience to light interference and contributes to its accuracy. The specified sensor distance is a key aspect of the design, aiming to achieve precise and reliable detection. The device is thoughtfully crafted to meet these specifications, providing a visual representation in the illustration below, as presented by the author.

Top View **Sample Data Collection**

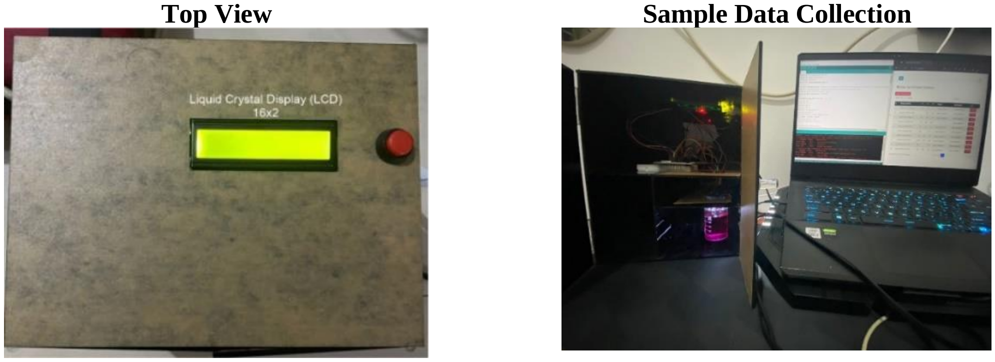

Fig. 8. Tool Instrumentation Design

This design in Fig. 8 aligns with the literature on IoT-based formalin detection instruments, acknowledging the importance of material selection for casing, the inclusion of an LCD for user interface, and the critical role of specified sensor distances in ensuring accurate and reliable detection results. The integration of Fuzzy Logic in conjunction with IoT technology in the design of the formalin detection instrument signifies a strategic and advanced approach. Fuzzy Logic, as a mathematical concept, allows for the modeling of uncertainty and imprecision in decision-making processes, providing a more nuanced and context-aware analysis. This is particularly relevant in the context of formalin detection methodologies, where the presence of the substance can vary in concentration and context.

B. *Software Implementation*

The software implementation phase is an important step in the development cycle or implementation process of a website designed to monitor and detect formaldehyde levels in chickens. The approach adopted involves the use of real-time language methods for data representation. In line with the literature and theoretical framework, this phase is very important because it contributes to the overall function and usability of the formalin detection system. In this context, the website in Fig. 9 is designed to function as a monitoring platform, utilizing advanced software to provide real-time insight into formaldehyde levels in chickens..

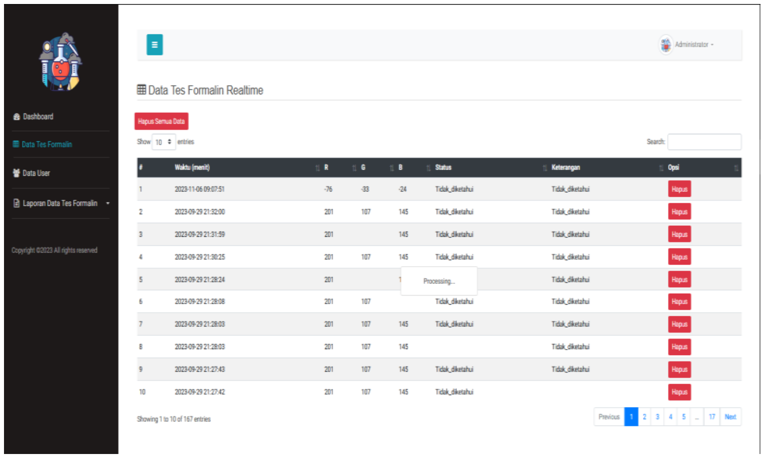

Fig. 9. Formalin Level Test Data Page

The utilization of real-time language methods is in line with contemporary literature that emphasizes the importance of real-time data updates in monitoring systems, ensuring timely and accurate information. Figure 10 shows a website visualization that shows how much real-time data has been detected for further investigation by the authorities. For Figure 11, the website admin can see who is using this website, if there are other users who are not known, the admin can remove the account from the website. Figure 12 is real-time data monitoring, the same as Figure 10, but in graphic form that can be monitored only on a daily basis

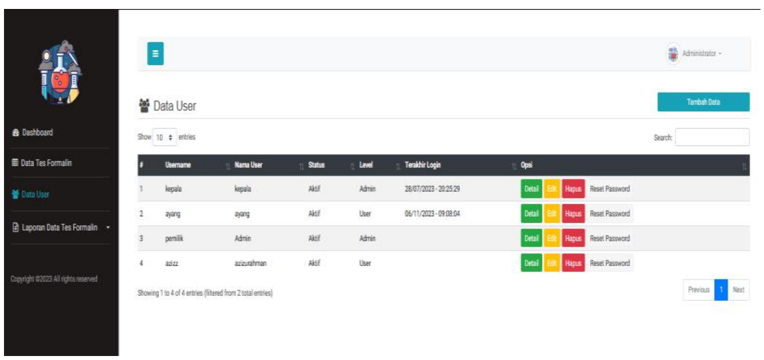

Fig. 10. User Data Page on Admin Account

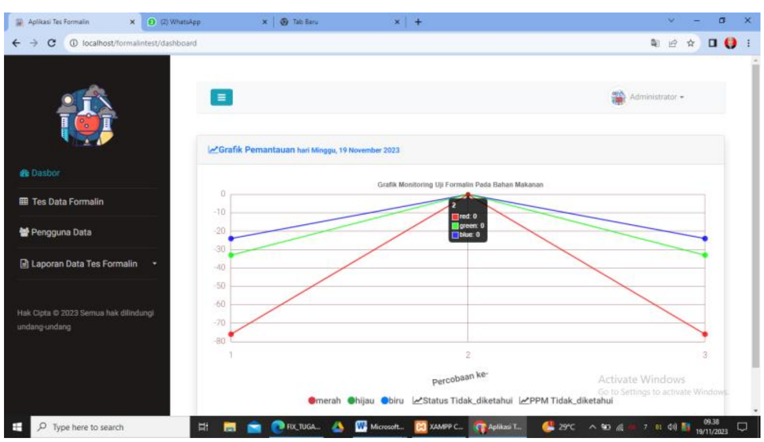

Fig. 11. Formalin Level Testing Data Monitoring Chart

C. *Hardware Implementation*

The hardware implementation phase involves the assembly of carefully selected components to create the IoT-based Formalin Detection Device for Chicken. The hardware components meticulously chosen by the author for this implementation include the ESP8266, Liquid Crystal Display (LCD), Breadboard, Jumper Cables, and the TCS3200 Color Sensor. Drawing from relevant literature and established theories in IoT-based systems, the selection of the ESP8266 as the core module aligns with its well-documented capabilities for wireless communication and data transfer. The integration of an LCD serves as an essential user interface, allowing for real-time data visualization and enhancing user interaction with the device. The use of a Breadboard and Jumper Cables facilitates a modular and flexible hardware setup, ensuring ease of assembly and potential future modifications. Additionally, the incorporation of the TCS3200 Color Sensor corresponds to established methodologies in color-based sensing for various applications. This comprehensive hardware implementation, guided by both literature and theoretical considerations, contributes to the creation of a robust and effective IoT-based instrument for formalin detection in chicken products.

D. *Sample Testing*

Based on Fig. 12, there are samples made by the author with levels of 0 ppm, 40 ppm, 80 ppm, and 200 ppm where the differences can be seen. The higher the ppm, the more intense the color resulting from making this sample. Then based on Fig. 13, this is how to collect data on chicken samples that have been made which will be uploaded via the ESP8266 Module, and the test results to obtain this data will be displayed as in Fig 14 that gives the results of the RGB values, formaldehyde status from low, strong, or not known and described. To read all the results obtained from this test, you only need adequate hardware (Laptop).

Fig. 12. Sample Preparation

Fig. 13. Program Upload Process to ESP8266 Module

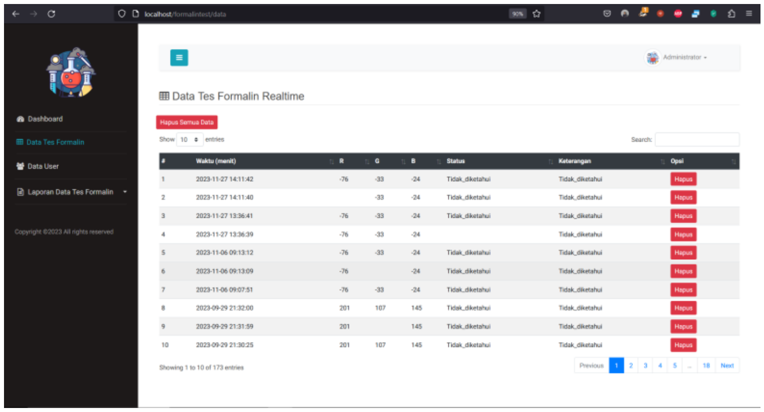

Fig. 14. Final Results of Formalin Level Test Testing

V. CONCLUSION

This research represents an effort to develop an innovative solution for detecting formalin levels in chicken using an Internet of Things (IoT)-based device and the TCS3200 color sensor. By employing a sensitive color sensor connected to the internet, this device is capable of detecting color changes in formalin-contaminated slaughtered chicken. Through data processing and communication executed by the ESP8266 microcontroller, information about the detection results can be accessed at any time for further analysis. The increasing demand for safe and healthy food emphasizes the importance of monitoring food quality, including the detection of harmful substances like formalin. This device is designed to have the potential to contribute to ensuring safe and high-quality food for the community.

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