

# Design and Implementation of a Detection System for pH Levels, Moisture Content, and Sweetness in Honey

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**Abstract**— This research aims to design and build a honey detection device. The device is designed to detect three important parameters in honey such as pH, water content, and color. A pH sensor is used to measure the acidity level of honey, which is an important indicator in determining the freshness and quality of honey. A Soil Moisture sensor is adapted to measure the water content in honey, as the appropriate moisture level significantly affects the stability and quality of honey. Meanwhile, an LDR sensor is used to detect the color of honey, which often serves as a visual indicator of the quality and type of honey. Data collected from these three sensors is processed by an ESP32 and displayed in Liquid Crystal Display (LCD) with easily understandable format, enabling users to assess honey quality quickly and accurately. Test results show that this device can provide consistent and reliable data, making it a potential solution for honey quality evaluation in the field. This research also utilizes push buttons for displaying data and resetting or reconfiguring the system. Based on the testing conducted, Uray Honey has the highest water content (11.90%) and the lowest acidity level (4.67). Real Honey with water content (8.19%) and pH (3.43), and TJ Honey with water content (8.68%) and pH (3.41) have similar profiles in terms of water content and pH; however, Real Honey is darker in color (11.05) compared to Uray Honey (9.97). Super Honey has consistent color and water content (8.11%) but has a lower color value (9.59) compared to other honeys and has a pH of (3.41).

**Keywords**— Honey; ESP32; Soil Moisture Sensor; pH Sensor; LDR Sensor; LCD; Push Button.

Manuscript received 5 Jan. 2026; revised 10 Jan. 2026; accepted 25 Jan. 2026. Date of publication 30 Jan. 2026.

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## I. INTRODUCTION

Honey is a non-timber forest product rich in benefits, including its use as a health supplement and energy booster. Honey contains a natural sweet liquid produced by bees from various nectar sources, so that nectar being the fluid secreted by plant glands that contains various types of carbohydrates, including sucrose, fructose, and glucose. Honey is a thick liquid resembling syrup with a sweet taste similar to sugar solution. The role of honey in health has been widely proven scientifically. Regular honey consumption is also associated with reduced risk of several diseases, particularly digestive organ infections. Honey is a natural sweetener and nutritious food. Honey is used as traditional medicine in communities. Honey acts as a compound that can prevent and treat several diseases caused by bacteria and viruses. Honey possesses

therapeutic capabilities as an anti-inflammatory, antimicrobial, gastrointestinal health agent, neurological health agent, anti-cancer, antidiabetic, and antioxidant[1].

According to [2], the glucose content in honey can reach up to 5%, the maximum allowable water content is 22%, and the acid value must not exceed 50 ml NaOH/kg (Nasional, 2013).

Producing natural honey requires considerable cost due to the lengthy harvesting process. Given that honey is largely composed of carbohydrates, many producers intentionally adulterate their products by mixing glucose and fructose syrup with honey that has not yet reached proper maturity for harvest. This practice enables producers to maximize profits while minimizing production costs[3].

A study by [4], aims to determine the quality of local honey from five villages in Temanggung Regency. The preparation for moisture content and total sugar testing was conducted

using the refractometry method, while acidity levels were measured via acid-base titration. The results indicated that different geographical locations had a significant effect on the water content, total sugar, and acidity of the studied honey. The highest honey quality was found in rubber honey from Medari Village, with a moisture content of 20.9%, a total sugar content of 77.5%, and an acidity level of 34.59 ml NaOH/kg, values of which closely align with the Indonesian National Standard (SNI-2013) for honey.

A study by [5], aims to determine photodiode characteristics, develop a detection system for pure honey and sugar-solution-adulterated honey, and test the system on pure longan honey samples as well as honey mixed with palm sugar solution. The photodiode characterization process which includes the transfer function, input-output relationship, sensitivity, and repeatability was conducted by varying the light intensity of the LED. In the development of the detection system, the sensor circuit utilizes a voltage divider circuit consisting of a resistor and a photodiode. Sample testing was performed using pure honey, as well as honey mixed with 25% and 50% palm sugar solutions. The characterization results showed that the photodiode has a transfer function of  $V = 0.0221 I + 0.3633$ , a very strong input-output relationship with a correlation coefficient of  $r = 0.99$ , a sensor sensitivity of 0.0221 volt/lux, and a repeatability of 89.44%. The developed detection system achieved a 100% success rate.

A study by [6], utilizes an RGB sensor to differentiate the colors of various honey types, specifically stingless bee (Kelulut) honey, regular honey, and bitter honey. The testing results were compared against a refractometer as a benchmark. Furthermore, a soil moisture sensor was employed to measure the moisture content of Kelulut honey in comparison with regular and bitter honey varieties. Additionally, a pH sensor was used to measure the acidity levels of Kelulut honey after conducting proper sensor calibration.

To combat this fraud, laboratory testing is required. However, laboratory analysis becomes impractical when immediate and rapid results are needed. Therefore, new technology is necessary to detect adulterants in commercially available honey. Adulteration in honey can be assessed based on two parameters: color and water content. Darker honey typically indicates higher sugar content. When examining sugar concentration, higher sugar levels cause light passing through the analyzer to become dimmer.

Fundamentally, there is no single definitive test for honey authenticity. However, honey testing can be conducted using light intensity parameters since honey is a transparent liquid that allows light to pass through. The current instrument for measuring light intensity is the LDR (Light Dependent Resistor) sensor. An LDR is a light-sensitive sensor whose resistance changes according to the intensity of light received, conducting electrical current in the forward direction. In this research, an LED (Light Emitting Diode) serves as the light source as in [5].

This research aims to test honey based on its sugar content and water viscosity. The findings can help identify excessive adulteration in honey products.

## II. MATERIALS AND METHOD

The design and development of this research requires a block diagram to illustrate the operational workflow of the device for detecting pH levels, water content, and sweetness levels in honey.

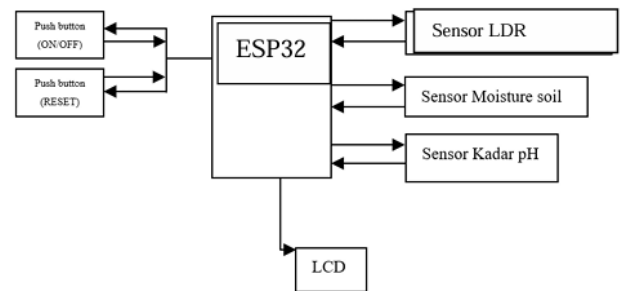


Fig. 1 Block diagram honey detection device

This device utilizes an ESP32 microcontroller and using three sensors: an LDR sensor to measure sweetness based on color intensity, a soil moisture sensor to determine water content, and a pH sensor to measure acidity levels. Once the data is collected and processed, the results are displayed on an LCD screen. The following flowchart illustrates the operational workflow of this device.

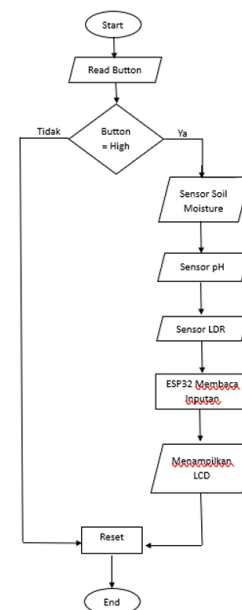


Fig. 2 Flowchart honey detection device

### A. Device Schematic

The circuit schematic of this device consists of an ESP32 microcontroller connected to three sensors: an LDR sensor, a Soil Moisture sensor, and a pH sensor. These sensors function as input signals to collect data on honey content. The output will be displayed on LCD screen.

For the power supply, the positive terminal of the battery is connected to the VIN pin of the ESP32 as the power input, while the negative terminal is connected to ground pin. This device incorporates two push buttons, where the positive pin of each push button is connected to the VIN pin input of the ESP32 and the negative pin is connected to ground pin.

The circuit uses an I2C module to interface between the LCD and the ESP32 microcontroller. The I2C module has four pins: Vcc pin connected to VIN/5V pin on the ESP32, ground pin connected to ESP32 ground pin, SDA pin connected to GPIO21 pin, and SCL pin connected to GPIO22 pin.

The soil moisture sensor has two pins: Vcc pin connected to VIN/5V pin on the ESP32 and ground pin connected to ESP32 ground pin. The pH sensor has *three* pins: Vcc pin and ground pin connected to the ESP32's corresponding pins, and A0 pin serving as the analog signal input. Lastly, the LDR sensor has three pins: D0 pin connected to D34 pin on the ESP32, Vcc pin connected to VIN pin, and ground pin connected to ESP32 ground pin.

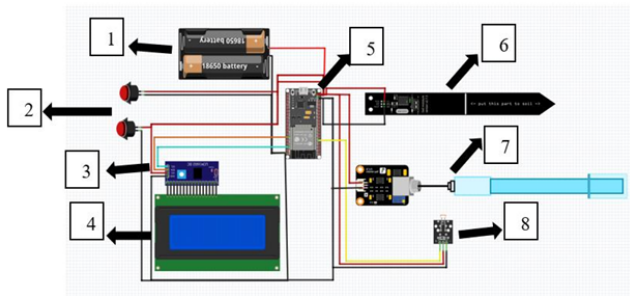


Fig. 3 Honey detection device schematic

Description:

1. Battery
2. Push button
3. I2C
4. LCD
5. ESP32
6. Soil Moisture Sensor
7. pH Sensor
8. LDR Sensor

### B. Mechanical Design

The mechanical design of this device features three sample holes, each designated for a specific sensor. The first hole accommodates the soil moisture sensor sample for detecting water content. The second hole is used for color sampling using the LDR sensor. The third hole is designated for the pH sensor, equipped with a cover that serves as a reservoir for honey diluted with distilled water.

The device includes an LCD screen that displays the output data from all three sensors during honey detection. Additionally, two push buttons are incorporated into the design. The first push button functions to reset or restart the sensors for testing the next honey sample, while the yellow push button functions to stop and hold the sensor output readings.

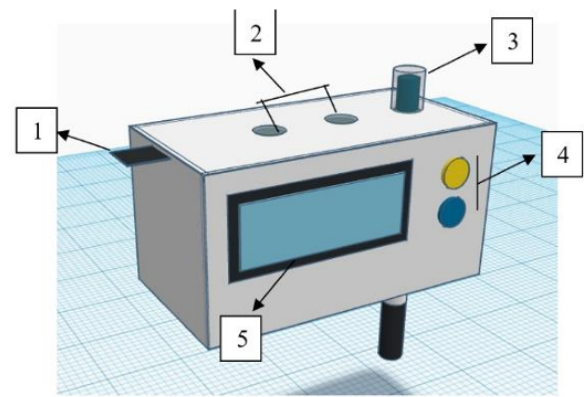


Fig. 4 Honey detection device mechanical design

Description:

1. Soil Moisture Sensor Battery
2. Sample hole
3. pH Sensor I2C
4. Push button
5. LCD

### C. Experimental Methodology

In this research, the following tests were conducted:

#### 1. LDR Sensor Testing

The LDR sensor is used to detect and measure honey color through light bias emitted from a super bright LED light source. Testing was performed by placing a honey sample on a glass slide to determine the ADC voltage output from the LDR sensor.

#### 2. Soil Moisture Sensor Testing

The soil moisture sensor is used to measure the water content viscosity in honey. Testing was conducted by dropping the honey sample onto the sensor surface.

#### 3. pH Meter Kit Sensor Testing

The pH meter kit sensor is used to measure the acidity level (pH) of honey. Testing was conducted by dropping the honey sample onto the tip of the pH electrode probe, which then produces an analog or digital output signal.

## III. RESULT

### A. LDR Sensor Testing

The following are the average results obtained from the LDR Sensor with 5 attempt testing for each type of honey shown in Table 1.

TABLE I  
AVERAGE RESULT OF COLOR DETECTION USING LDR SENSOR

Honey Type	Color		Accuracy (%)
	LDR Sensor	Lux Meter Instrument	

Real Honey	11.29	9.96	86.65
TJ Honey	10.21	9.24	89.50
Uray Honey	9.74	7.51	70.31
Super Honey	9.60	7.16	65.92

Based on the LDR sensor testing results for color detection in honey samples, TJ Honey demonstrates the highest accuracy at 89.50%, indicating the best correlation between the LDR sensor and the Lux Meter instrument readings. Real Honey follows with the second highest accuracy at 86.65%, demonstrating reliable sensor performance. Uray Honey shows a moderate accuracy of 70.31%, with a noticeable difference between the LDR sensor reading of 9.74 and the Lux Meter reading of 7.51. Super Honey has the lowest accuracy at 65.92%, showing the largest discrepancy between sensor and instrument values.

The accuracy range varies from 65.92% to 89.50%, with an average accuracy of approximately 78.10%. This indicates that while the LDR sensor can effectively detect color variations in different honey types, calibration improvements may be needed to enhance accuracy, particularly for darker honey samples such as Uray Honey and Super Honey.

#### B. Soil Moisture Sensor Testing

The following are the average results obtained from the Soil Moisture Sensor with 5 attempt testing for each type of honey shown in Table 2.

TABLE II  
AVERAGE RESULT OF WATER DETECTION USING SOIL MOISTURE SENSOR

Honey Type	Water Content		Accuracy (%)
	Soil Moisture Sensor	Moisture Meter Instrument	
Real Honey	7.81	7.56	96.69
TJ Honey	8.63	9.14	94.42
Uray Honey	11.68	12.34	94.65
Super Honey	8.52	8.32	97.60

Based on the soil moisture sensor testing results for water content detection in honey samples, Super Honey demonstrates the highest accuracy at 97.60%, followed by Real Honey at 96.69%. Uray Honey shows an accuracy of 94.65%, while TJ Honey has the lowest accuracy at 94.42%. Overall, the soil moisture sensor readings show minor variations compared to the Moisture Meter instrument readings across all honey samples. The accuracy range varies from 94.42% to 97.60%, with an average accuracy of approximately 95.84%.

Among the honey samples tested, Uray Honey has the highest water content at 11.68%, which exceeds the maximum allowable water content of 22% as specified in SNI 01-3545-2013, indicating that all tested honey samples meet the Indonesian national standard for water content. Real Honey has

the lowest water content at 7.81%, suggesting better quality in terms of moisture stability. This indicates that the soil moisture sensor provides highly reliable measurements for detecting water content in honey, with all samples achieving accuracy levels above 94%.

#### C. pH Sensor Testing

The following are the average results obtained from the pH Sensor with 5 attempt testing for each type of honey shown in Table 3.

TABLE III  
AVERAGE RESULT OF WATER DETECTION USING SOIL MOISTURE SENSOR

Honey Type	pH Level		Accuracy (%)
	pH Sensor	pH Meter Instrument	
Real Honey	9.96	5.20	8.46
TJ Honey	9.24	4.43	8.58
Uray Honey	7.51	6.89	91
Super Honey	7.16	5.83	77.19

Based on the pH sensor testing results for acidity detection in honey samples, Uray Honey demonstrates the highest accuracy at 91.00%, indicating the best correlation between the pH sensor and the pH Meter instrument readings. Super Honey follows with an accuracy of 77.19%, demonstrating relatively stable sensor performance for this specific sample. However, Real Honey shows a significantly lower accuracy of 8.46%, with a large discrepancy between the pH sensor reading of 9.96 and the pH Meter reading of 5.20. TJ Honey has the lowest accuracy at 8.58%, showing the most substantial deviation where the sensor recorded a basic value (9.24) while the instrument measured an acidic value (4.43).

The accuracy range varies drastically from 8.58% to 91.00%, with an average accuracy of approximately 41.99%. This indicates that while the pH sensor shows potential in detecting acidity for samples like Uray Honey, its overall reliability is inconsistent across different honey types. The high deviation, particularly in Real Honey and TJ Honey where readings shifted toward the alkaline scale suggests that the sensor requires intensive calibration or may have limitations in accurately measuring highly acidic substances without proper compensation.

#### IV. CONCLUSION

The results of this experiment indicate that Uray Honey has the highest moisture content and the lowest acidity level, which may influence its shelf life and flavor profile. Real Honey and TJ Honey share similar profiles regarding moisture content and pH levels, although Real Honey is darker in color. Super Honey exhibits consistent color and moisture content, yet it ranks lower in color intensity compared to the other varieties. Overall, Uray Honey appears to have higher moisture and pH levels than the other honey types, suggesting distinct characteristics in its chemical composition and moisture properties. Uray Honey has the highest water content (11.90%)

and the lowest acidity level (4.67). Real Honey with water content (8.19%) and pH (3.43), and TJ Honey with water content (8.68%) and pH (3.41) have similar profiles in terms of water content and pH; however, Real Honey is darker in color (11.05) compared to Uray Honey (9.97). Super Honey has consistent color and water content (8.11%) but has a lower color value (9.59) compared to other honeys and has a pH of (3.41).

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