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Design of a Coffee Blending Device with Carbon Monoxide Levels (Co) Based on Backpropagation Artificial Neural Network 2 Hidden Layers

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A R T I C L E I N F O

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A B S T R A C T

Coffee is categorized into three types: robusta, arabica, and liberica. After roasting, gas formation occurs within the coffee beans. Freshly roasted coffee is not palatable and is not fit for consumption due to its high carbon content. The purpose of this research is to determine the best coffee for consumption based on carbon gas levels. Carbon monoxide (CO) is measured using an E-nose sensor. The determination of carbon monoxide levels is done using MQ-135, MQ-7, TGS 2602, and TGS 2620 sensors. The highest levels of carbon monoxide (CO) were found in Arabica coffee with a light roast level, with gas levels of 389 ppm and 34.21 ppm. The lowest levels of carbon monoxide (CO) were also found in Arabica coffee with a light roast level, with gas levels of 389 ppm and 34.21 ppm. Carbon monoxide (CO) levels were found in Robusta coffee with a dark roast level, with gas levels of 327 ppm and 25 ppm. To determine coffee identification using the artificial neural network method, the success rate was 98% for liberica, 100% for arabica coffee, and 98% for robusta coffe

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INTRODUCTION

Coffee is one of the plantation commodities that is widely enjoyed by the community. Products made from coffee are in great demand by the public so that more and more community businesses provide processed coffee products. Coffee plants are grouped into 3 types. namely robusta. arabica. and liberica coffee. Roasting is a unitary operation that is very important for developing specific organoleptic properties (aroma. taste and colour) that underlie coffee quality(Na'im et al., 2024). Roasted coffee beans should be left in an airtight place for some time for the release of carbon dioxide. but should not be left open for too long. as this will cause too much oxygen to enter the coffee and cause a decrease in the flavour. aroma and quality of the roasted coffee beans(Choe et al., 2023). Coffee is one of the beverage commodities traded in the global market (Daviron & Ponte, 2008). It is one of the most consumed beverages in the world after water and tea (Butt & Sultan, 2011)**.** Coffee and tea are beverages consumed by adults (Özen et al., 2015)(Herber-Gast et al., 2016). Coffee is used by many industries such as cosmetics (Rodrigues et al., 2023), pharmaceuticals (Konieczka et al., 2020)(Marto et al., 2016)], and medicine , among others. The health benefits of coffee, when consumed regularly every day, include reducing the risk of developing several disorders such as Parkinson's disease (Munoz & Fujioka, 2018), cirrhosis (Dranoff, 2018), and colon cancer (Shah & Kumar, 2020)**.**

Coffee that is just ready to be roasted is not tasty and not suitable for consumption. After the coffee is roasted, there will be a kind of gas formation that occurs in the coffee beans(Wang & Lim, 2014). The coffee roasting process also produces complex aroma compounds that give coffee its desired flavour and aroma characteristics. The composition of gases released from whole beans during the grinding process has been reported by Clarke and McRae as 87% carbon dioxide (CO2). 7.3% carbon monoxide (CO). and 5.3% nitrogen (N2). the remaining 2 (less than 1%) being volatile organic compounds (VOCs).(Cecilia et al., 2012)

The level of gas content after the coffee bean grinding process is difficult to determine by ordinary people. so special expertise is needed to determine the quality of coffee. Based on this description. in this study using the artificial intelligence method of Backpropagation Artificial Neural Network. it will be applied to identify the gas from the roasting process of coffee beans (Susanti, Aidha, et al., 2018). Therefore. the author took the title of the final project Designing a Coffee Blending Tool with Identification of Carbon Dioxide (CO2) and Carbon Monoxide (CO) Levels Based on Artificial Neural Networks. This tool is used to measure gas levels from coffee that has finished roasting and which will be consumed. In this tool using E-nose as a sensor to determine the levels of Carbon Dioxide (CO2) and Carbon Monoxide (CO) in coffee. there is a monitor that will display the levels of Carbon Dioxide (CO2) and Carbon Monoxide (CO). For the controller of this tool using Arduino UNO.

JST is also applied in various aspects of agricultural product processing, such as identifying the aroma and quality of coffee products, especially in Arabica and Robusta coffee (Susanti, Nofendra, & Ilhamdi, 2023). JST can even be utilized to control the mixing process of chayote chips dough automatically. Artificial Neural Networks (ANN) have been used for detecting coffee types, specifically Arabica and Robusta coffee (Susanti, Hidayat, et al., 2023)(Susanti, Ressy Aidha, et al., 2018).

LITERATUR RIIVIEW

After the roasting process, coffee may taste less pleasant because it still contains CO gas and methanol that have not been completely eliminated (Antonisfia et al., 2023). Consuming coffee with these gas contents can affect the taste. The degassing process is the release of CO gas and methanol that occurs naturally and constantly over a certain period of time (Smrke et al., 2018). The time required for the degassing process varies depending on the coffee bean variety, roasting type, and blending profile used. Degassing is an important stage to ensure the optimal quality and final taste of the coffee. Without proper degassing, coffee may have an unpleasant taste and aroma. Certain coffee bean varieties and different roasting methods require different degassing times to achieve the best results.

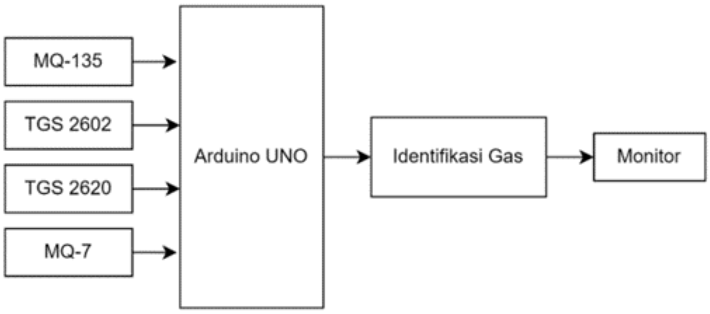
E-Nose (Electronic Nose) is an innovative sensor technology designed to detect and classify aromas from various volatile organic compounds (VOCs). This technology works similarly to the human or animal nose, where VOCs emitted by an object are recognized based on previously stored aromas in the brain. E-Nose consists of several sensors with partial specificity that can respond to various volatile compounds. When VOCs are released by an object, the E-Nose sensors detect these changes and analyze the resulting aroma patterns. This system allows for high-accuracy aroma recognition, similar to how the human nose distinguishes different aromas.

In the agricultural field, E-Nose has been widely used for various applications (Wilson, 2013)(Susanti, Nofendra, et al., 2023). One example is classifying varieties of shallots with an accuracy rate of 97.5%. This technology has also been used to identify and classify strawberries and apple varieties, demonstrating the ability of E-Nose to detect specific aromas for various types of crops. Relevant references show the effectiveness of E-Nose in agricultural applications (Fundurulic et al., 2023)(Susanti, Zaini, et al., 2023).

METHODOLOGY

Research Methodology

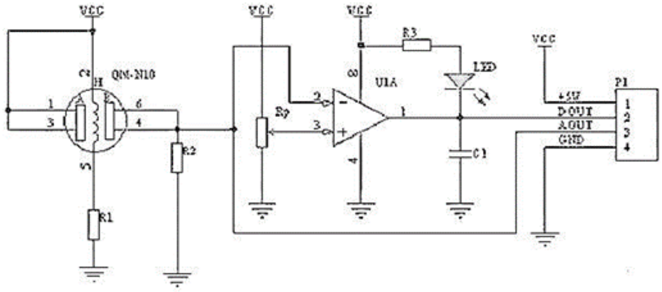
The design and workings of the tool in a block diagram is to make it easier to analyse the circuit as a whole. Starting from input. processing. to the final part of the process that will produce output or output from the circuit. The overall block diagram is shown in Picture 1 below.



Picture 1. Block Diagram of the Device

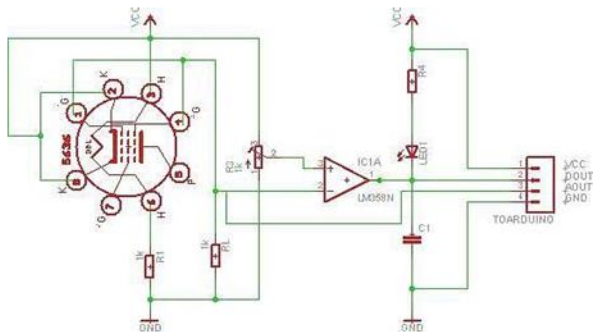
The following is an explanation of the function of each block in the diagram according to the order of the process flow: MQ-135. TGS 2602. TGS 2620. and MQ-7 (Gas Sensor): The first block consists of four different gas sensors. Each sensor has a specific function to detect a particular gas. MQ-135: Detects harmful gases such as ammonia. carbon dioxide (CO_2). smoke. and chemical vapours. TGS 2602: Detects volatile organic compounds (VOCs) such as methane and ethanol that are often found in the air. TGS 2620: Specialised for detecting alcohol gas (ethanol) and some other VOCs. MQ-7: Detects carbon monoxide (CO) gas which is harmful to health as it is odourless and colourless. The function of this block is to measure the concentration of gases in the environment and send raw data about the presence of those gases to the Arduino UNO

The working principle of this tool is when the ac motor is activated and the freshly roasted coffee with 3 levels. namely light. medium and dark. is immediately ground into coffee powder. The coffee is left in the coffee container and the MQ-135. MQ-7. TGS 2602 and TGS 2620 gas sensors used in this study will identify many gases formed after the coffee grinding process. Arduino software will programme the sensor to identify Carbon Dioxide (CO2) and Carbon Monoxide (CO) gas. The gas data is used to be input data for the identification process using artificial neural networks in Matlab software and then the identification results will be displayed on the Monitor. Based on the block diagram. this tool consists of MQ-135. MQ-7. TGS 2602 and TGS 2620 sensor inputs. For the design of the circuit connected to Arduino Uno is as follows figures 2. 3. 4. 5 to see the equivalent circuit of the sensor connected to the Arduino.



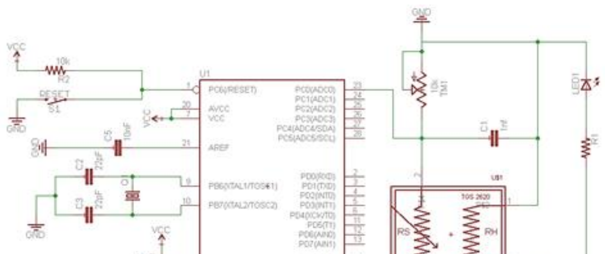
Picture 2. MQ-135 Sensor Circuit

The following is an explanation of this circuit. MQ-135 Gas Sensor. This sensor is usually used to detect certain gases. which are commonly used in gas detection applications. This sensor works on the principle of resistance change. When the sensor detects a gas. the resistance inside the sensor changes. resulting in a voltage variation at the output.



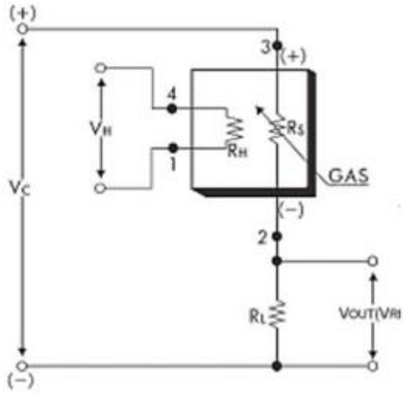
Picture 3. MQ-7 Sensor Circuit

The following is an explanation of the function of the components in this circuit. Gas Sensor. on the top left. you can see the MQ -7 gas sensor symbol which has several pins. such as H (heating) and A/B (anode and cathode). Pin H is the heating element in the sensor which is necessary for the sensor to work correctly in detecting gas. An electric current passes through the heating element for the heating sensor. allowing the resistance to change when gas is detected. Pins A and B are the resistance terminals of the sensor. which change when a certain gas is present around the sensor. This change results in a different voltage at the sensor output. which is used as the gas detection signal.



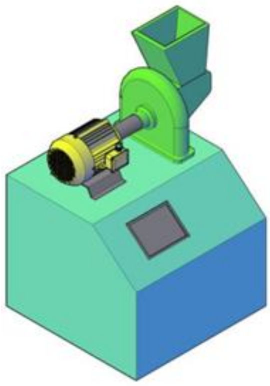
Picture 4. TGS 2602 Sensor Circuit

This image is a schematic of an electronic circuit that uses an Atmega328P microcontroller to process signals from a gas sensor. The following is an explanation of the function of the parts in this circuit. the power input and stabilisation parts of the circuit. R1. C1. C2. and C3. these capacitors function to filter and stabilise the voltage supply. so that the signal entering the microcontroller is more stable and not disturbed by noise. The 10k resistor is used to adjust the voltage level or as a pull-up or pull-down resistor on the input line.



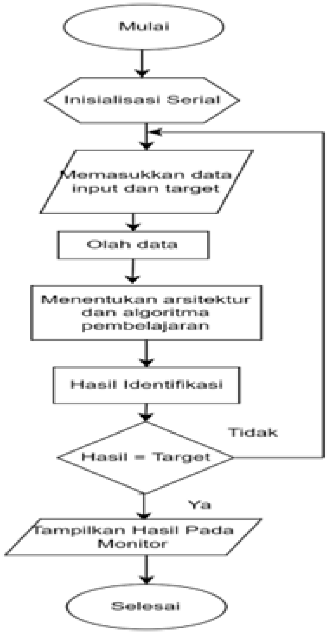
Picture 5. TGS2620 Sensor Circuit

The picture above is the basic scheme of the TGS 2620 gas sensor. the following is an explanation of the function of the component parts in this scheme. Heating Element (RH) is the heating element in the sensor. This element functions to heat the sensor to a certain operational temperature so that the sensor can detect gas effectively. This heating voltage is applied through the VH terminal to activate the heating element. When this element is active. the resistance in the sensor changes when the presence of gas is detected. Mechanical design is the design of hardware such as the body of the tool and other physical parts that will be made following this mechanical design design that has been calculated. according to Picture 6.



Picture 6. Tool Design

A flowchart is a flow chart used to illustrate steps. sequences. and decisions in a process or system. This diagram utilises certain symbols to represent activities. conditions. and logic flows. making it easier to understand complex processes. Picture 7 below is the backpropagation identification flowchart.



Picture 7. Backpropagation Identification Flowchart

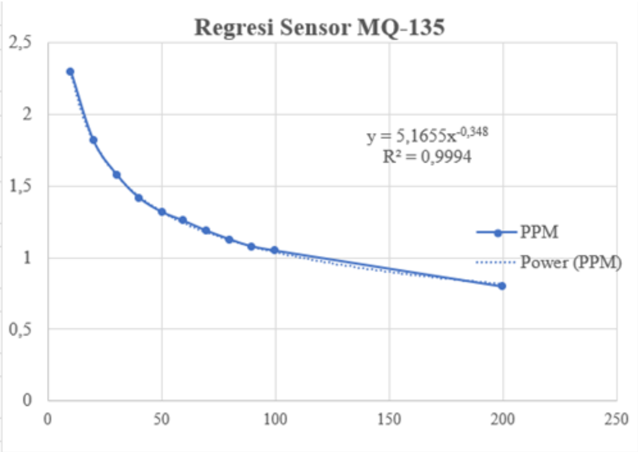
The JST Backpropagation Training process starts from identifying the aroma of coffee whose data will be carried out in the training process so that the weight value can be seen in Picture 8.

Picture 8. Proses Pelatihan Backpropagation

RESULTS AND DISCUSSION

Sensor calibration

MQ-135 Sensor Calibration for Co2 Gas Detection



Picture 9. MQ-135 Sensor Regression Graph

By using the regression method. the equation 5.1655x-0.348 is obtained which is the result of the relationship graph between the ppm value and the sensor resistance (rs/so). Description: y: equation output with the result in the form of ppm x: ratio value (rs/ro) rs: sensor resistance ro: sensor resistance when the gas concentration is known.

Carbon dioxide (CO2) in fresh air varies between 0.03% (300 ppm) to 0.06% (600 ppm) depending on the location.[19] After the output equation is obtained. it is necessary to take the ratio value. for the ratio value the rs and ro values are needed. where the rs obtained when vrl = 0.5 v is 314 ohms. the ro value can be obtained by approaching using equation 1.

$$y = 5{,}1655x^{-0{,}348} \ldots\ldots$$

$$400 = 5{,}1655x^{-0{,}348}$$

$$\frac{400}{5{,}1655} = x^{-0{,}348}$$

$$x^{-0{,}348} = 77{,}43$$

$$x = 0{,}0000037324$$

After we know the value of Rs/Ro. we can now find the value of Ro. using the rs/ro equation which can be seen in equation 2 below.

$$\frac{rs}{ro} = 0{,}0000037324\ldots\ldots\ldots$$

$$rs = 0{,}0000037324x\ ro$$

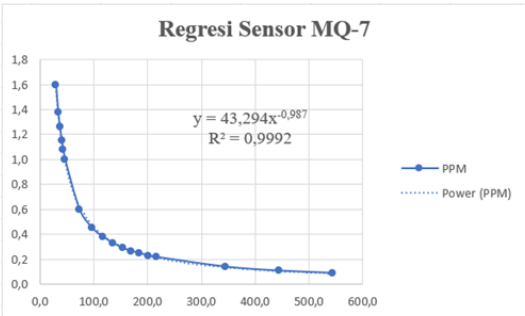
$$\frac{rs}{0{,}06208} = ro$$

$$ro = \frac{314}{0{,}0000037324}$$

Because the value of ro is a fixture. whether in ppm conditions. the value of ro is the same. After we know the ro value. we can find ppm using equation 3.

$$y = 5{,}1655x^{-0{,}348}\ldots\ldots$$

Calibration of MQ-135 sensor for co gas detection



Picture 9. Graphical Form of the MQ-7 Sensor Regression

By using the regression method. the equation 43.249x -0.987 is obtained which is the result of figure 11 which is the relationship between ppm value and sensor resistance (rs/ro).

Description: y: equation output with results in the form of ppm x: ratio value (rs/ro) rs: sensor resistance ro: sensor resistance when the gas concentration is known , According to the Regulation of the Minister of Labour and Transmigration number PER.13/MEN/X/2011 concerning Threshold Values for Physical Factors and Chemical Factors in the Workplace. CO has a Threshold Value (NAB) of 25 ppm [20]. After the output equation is obtained. it is necessary to take the ratio value. for the ratio value. the rs and ro values are needed. where the rs obtained when vrl = 0.5 v is 9240 ohms. the ro value can be obtained by approaching using equation 4.

$$y = 43{,}294x^{-0{,}987} \ldots\ldots\ldots$$

$$20 = 43{,}294x^{-0{,}987}$$

$$\frac{20}{43{,}294} = x^{-0{,}987}$$

$$x^{-0{,}987} = 0{,}461957$$

$$x = 2{,}18684$$

After we know the value of Rs/Ro. we can now find the value of Ro. using the rs/ro equation which can be seen in equation 5 below:

$$\frac{rs}{ro} = 2{,}18684 \ldots\ldots\ldots\ldots\ldots$$

$$rs = 2{,}18684 \times ro$$

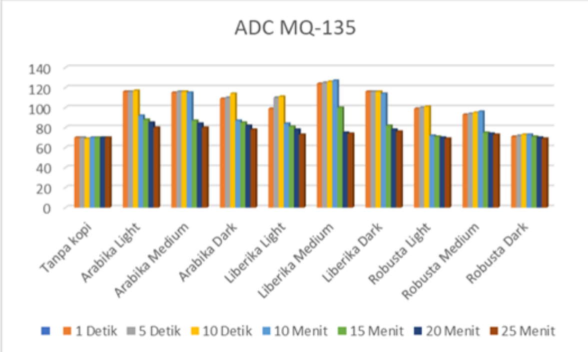
$$\frac{rs}{2{,}18684} = ro$$

$$ro = \frac{9240}{2{,}18684}$$

Because the value of ro is a determination. whether in conditions of 20 ppm or 100 ppm or other conditions. the Ro value is the same. After we know the ro value. we can find ppm using equation 6. Sensor Respone; data collection of MQ-135. TGS 2602. TGS 2620. MQ-7 sensor responses was carried out for 1 minute 10 seconds and data was collected for 1 second. 5 seconds. 10 seconds. 10 minutes. 15 minutes. 20 minutes and 25 minutes with a coffee weight of 15gr. Air without using coffee powder is free air around the coffee container that has been ground. container for coffee that has been ground. Measurement of the sensor response graph is done in three ways. among others:

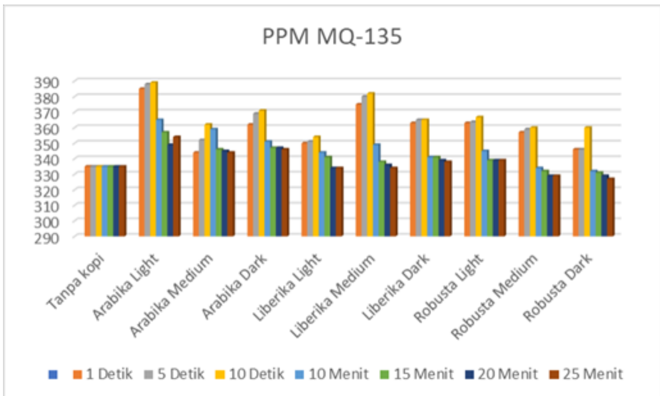
1. Without coffee
2. Using arabica coffee powder
3. Using robusta coffee powder
4. Using liberica coffee powder.

Sensor data collection using coffee powder is done by placing the sensor in a closed container of coffee powder. so that the air detected by the coffee is only the air contained in the coffee powder container. where there are arabica. liberica and robusta coffee grounds with 3 roasting levels. namely light. medium and dark. MQ-135 Sensor Response measurement of the ADC value of the MQ-135 sensor against no coffee. arabica. liberica and robusta coffee can be seen in Picture 10.



Picture 10. MQ-135 Sensor ADC Value Graph

In the graph. it can be seen that the ADC value of the sensor without coffee is 70. Medium Liberica coffee has the highest value among all coffees at 127. The response of Arabica coffee roasting light. medium. dark and Liberica coffee roasting light is almost the same with ADC values of 117. 116. 114. 111. The lowest ADC value on the MQ-135 sensor is found in robusta coffee with a dark roasting level of 69. Measurement of the PPM value of the MQ-135 sensor against no coffee. arabica. liberica and robusta coffee can be seen in Picture 11.



Picture 11. Graph of PPM Value of MQ-135 Sensor

In the graph. it can be seen that the PPM value of the sensor without coffee is 335 ppm. Arabica Light coffee has the highest value in data collection when 10 seconds is 389 ppm. The second highest value is seen in Liberika Medium coffee on data collection when 10 seconds of 382 ppm. The response of roasting medium Arabica coffee. dark Arabica coffee. light Liberica. dark Liberica. robusta light and robusta medium is almost the same with a value range of 329-371 ppm. The lowest PPM value found in robusta coffee with dark roasting level is 327 ppm. Measurement of the PPM value of the MQ-135 sensor against no coffee arabica. liberica and robusta coffee can be seen in Table 1.

Table 1. MQ-135 Sensor Value Data Retrieval Table

Pengukuran	Tanpa Kopi	Arabika Light	Arabika Medium	Arabika Dark	Liberika Light	Liberika Medium	Liberika Dark	Robusta Light	Robusta Medium	Robusta Dark
1 Detik	0.33	0.58	0.55	0.55	0.49	0.59	0.55	0.47	0.43	0.34
5 Detik	0.33	0.58	0.56	0.54	0.50	0.59	0.55	0.47	0.44	0.35
10 Detik	0.33	0.58	0.56	0.55	0.51	0.58	0.55	0.48	0.45	0.37
10 Menit	0.33	0.47	0.55	0.41	0.42	0.57	0.54	0.35	0.46	0.34
15 Menit	0.33	0.46	0.46	0.41	0.42	0.56	0.41	0.35	0.37	0.34
20 Menit	0.33	0.46	0.45	0.40	0.40	0.35	0.40	0.35	0.36	0.33
25 Menit	0.33	0.45	0.45	0.38	0.39	0.35	0.39	0.35	0.36	0.32

Voltage testing using the formula from can be seen in equation 7:

$$Tegangan = ADC \times \frac{Vref}{1023} \quad (7)$$

If the ADC value is known to be 70 and Vref 5 volts. the voltage value is obtained can be seen in the following equation 8:

$$Tegangan = 70 \times \frac{5}{1023} = 0{,}34\ volt \quad (8)$$

If the ADC value is 127 and Vref is 5 volts. the voltage value can be seen in equation 9 below:

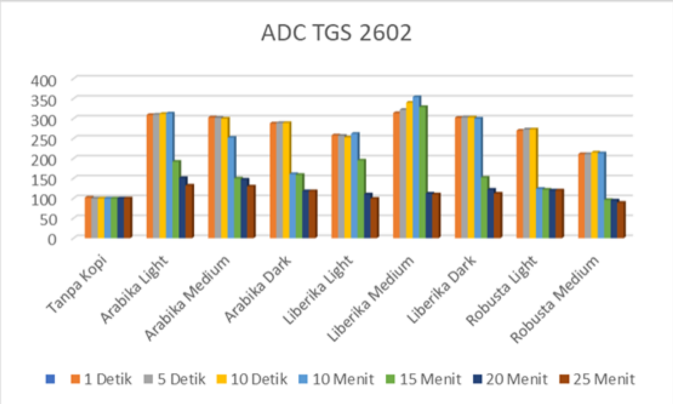
$$Tegangan = 127 \times \frac{5}{1023} = 0{,}62\ volt \quad (9)$$

If the ADC value is 69 and Vref is 5 volts. the voltage value can be seen in equation 10 below:

$$Tegangan = 69 \times \frac{5}{1023} = 0{,}33\ volt \quad (10)$$

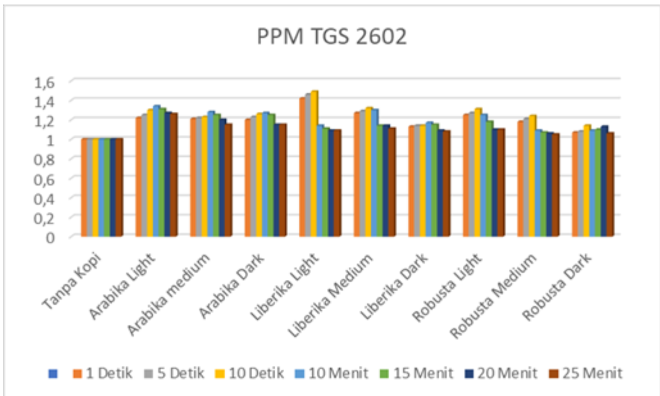
TGS 2602 Sensor Response

Measurement of the ADC value of the TGS 2602 sensor against no coffee. arabica. liberica and robusta coffee can be seen in Picture 12.



Picture 12. ADC Value Graph of TGS 2602 Sensor

In the graph. it can be seen that the ADC value of the sensor without coffee is 100. Liberica coffee medium roasting level is the highest value in data collection when 10 minutes is 354. The response of Arabica coffee roasting light. medium. dark. Liberica coffee roasting light. dark and robusta coffee roasting dark is almost the same with an ADC value range of 95-309. The lowest ADC value is found in robusta coffee with a medium roasting level at data collection when 25 minutes is 89. Measurement of the PPM value of the TGS 2602 sensor against no coffee. arabica. liberica and robusta coffee can be seen in Picture 14.



Picture 13. Graph of PPM Value of TGS 2602 Sensor

In the graph. it can be seen that the PPM value of the sensor without coffee is 1 ppm. Liberica coffee roasting light level is the highest value in data collection when 10 seconds of 1.49 ppm. The response of Arabica coffee roasting light. medium. dark. liberica coffee roasting medium. dark and robusta coffee roasting light and dark is almost the same with a value range of 1.06-1.32 ppm. The lowest PPM value is found in robusta coffee with a medium roasting level at data collection when 25 minutes is 1.05 ppm. Measurement of the PPM value of the TGS 2602 sensor against no coffee. arabica. liberica and robusta coffee can be seen in Table 2.

Table 2. TGS 2602 Sensor Value Retrieval Table

Pengukuran	Tanpa Kopi	Arabika Light	Arabika Medium	Arabika Dark	Liberika Light	Liberika Medium	Liberika Dark	Robusta Light	Robusta Medium	Robusta Dark
1 Detik	0.47	1.51	1.49	1.28	1.29	1.59	1.45	1.32	1.01	0.47
5 Detik	0.47	1.5	1.48	1.29	1.28	1.6	1.46	1.33	1.01	0.5
10 Detik	0.47	1.49	1.47	1.31	1.25	1.62	1.46	1.36	1.03	0.58
10 Menit	0.47	1.49	1.26	0.80	1.30	1.6	1.45	0.80	1.02	0.7
15 Menit	0.47	1.48	1.01	1.80	1.1	1.59	0.83	0.80	0.47	0.6
Pengukuran	Tanpa Kopi	Arabika Light	Arabika Medium	Arabika Dark	Liberika Light	Liberika Medium	Liberika Dark	Robusta Light	Robusta Medium	Robusta Dark
20 Menit	0.47	1.46	1.01	1.56	0.55	0.57	0.61	0.62	0.47	0.45
25 Menit	0.47	1.42	1.00	1.56	0.55	0.57	1.60	0.62	0.43	0.45

If the ADC value is 69 and Vref is 5 volts. the voltage value can be seen in equation 11 below :

$$Tegangan = ADC \times \frac{Vref}{1023} \quad (11)$$

If the ADC value is 100 and Vref is 5 volts. the voltage value can be seen in equation 12 below :

$$Tegangan = 100 \times \frac{5}{1023} = 0{,}48\ volt \quad (12)$$

If the ADC value is 354 and Vref is 5 volts. the voltage value can be seen in equation 13 below :

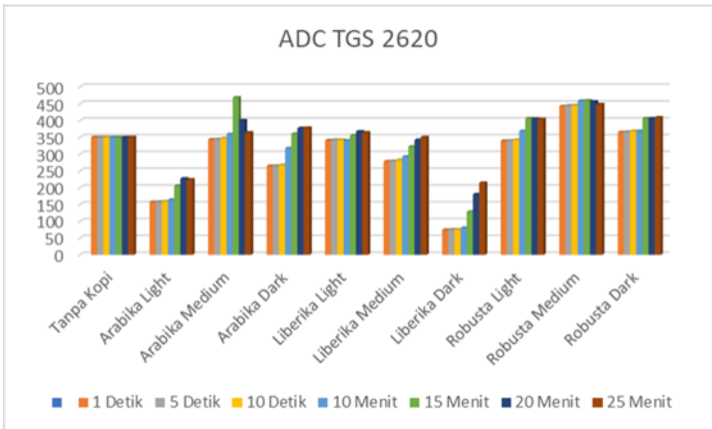
$$Tegangan = 354 \times \frac{5}{1023} = 1{,}73\ volt \quad (13)$$

If the ADC value is 89 and Vref is 5 volts. the voltage value can be seen in equation 14 below :

$$Tegangan = 89 \times \frac{5}{1023} = 0{,}43\ volt \quad (14)$$

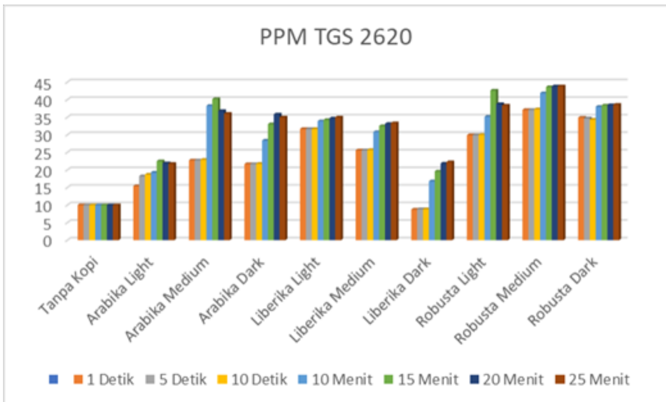
TGS 2620 Sensor Response

The measurement of the ADC value of the TGS 2620 sensor against no coffee. arabica. liberica and robusta coffee can be seen in Picture 14.



Picture 14. ADC Value Graph of TGS 2620 Sensor

In the graph. it can be seen that the ADC value of the sensor without coffee is 350. Arabica coffee medium roasting level is the highest value in data collection when 15 minutes is 468. The response of Arabica coffee roasting light. dark. Liberica coffee roasting light. medium and Robusta coffee roasting light. medium and dark is valued from 157-459. The lowest ADC value is found in Liberica coffee with a dark roasting level at data retrieval when 1 second is 74. Measurement of the PPM value of the TGS 2620 sensor against no coffee. arabica. liberica and robusta coffee can be seen in Picture 15.



Picture 15. Graph of PPM Value of TGS 2620 Sensor

In the graph. it can be seen that the PPM value of the sensor without coffee is obtained 10. Robusta coffee medium roasting level is the highest value in data collection when 20 minutes is 43.82. The response of Arabica coffee roasting light. medium. dark. Liberica coffee roasting light. medium and robusta coffee roasting light. dark is worth from 15.41-40.21. The lowest PPM value is found in Liberica coffee with a dark roasting level at data collection when 1 second is 8.75. Measurement of the PPM value of the TGS 2620 sensor against no coffee. arabica. liberica and robusta coffee can be seen in Table 3.

Table 3.TGS 2620 Sensor Value Data Detrieval Table

Pengukuran	Tanpa Kopi	Arabika Light	Arabika Medium	Arabika Dark	Liberika Light	Liberika Medium	Liberika Dark	Robusta Light	Robusta Medium	Robusta Dark
1 Detik	1.71	0.76	1.69	1.30	1.69	1.37	0.37	1.70	2.16	1.81
5 Detik	1.71	0.76	1.69	1.31	1.7	1.39	0.37	1.70	2.18	1.82
10 Detik	1.71	0.76	1.70	1.31	1.71	1.38	0.37	1.67	2.21	1.82
10 Menit	1.71	0.80	1.74	1.54	1.7	1.52	0.39	1.77	2.29	1.81
15 Menit	1.71	1.00	2.28	1.76	1.74	1.47	0.62	1.96	2.28	1.81
20 Menit	1.71	1.10	1.94	1.84	1.78	1.47	0.87	1.95	2.27	1.91
25 Menit	1.71	1.10	1.80	1.84	1.77	1.46	1.03	1.95	2.27	1.91

Voltage testing using the formula from the data can be seen in equation 15:

$$Tegangan = ADC \times \frac{Vref}{1023} \qquad (15)$$

If the ADC value is 350 and Vref is 5 volts. the voltage value can be seen in equation 16 below :

$$Tegangan = 350 \times \frac{5}{1023} = 1{,}71\ volt \qquad (16)$$

If the ADC value is 108 and Vref is 5 volts. the voltage value can be seen in equation 17 below :

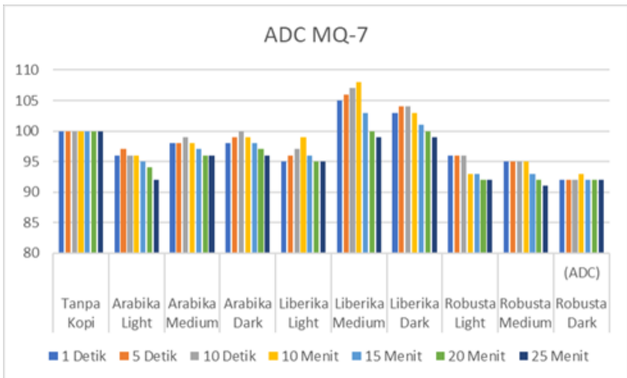
$$Tegangan = 468 \times \frac{5}{1023} = 0{,}52\ volt \qquad (17)$$

If the ADC value is 91 and Vref is 5 volts. the voltage value can be seen in equation 18 below :

$$Tegangan = 74 \times \frac{5}{1023} = 0{,}36\ volt \qquad (18)$$

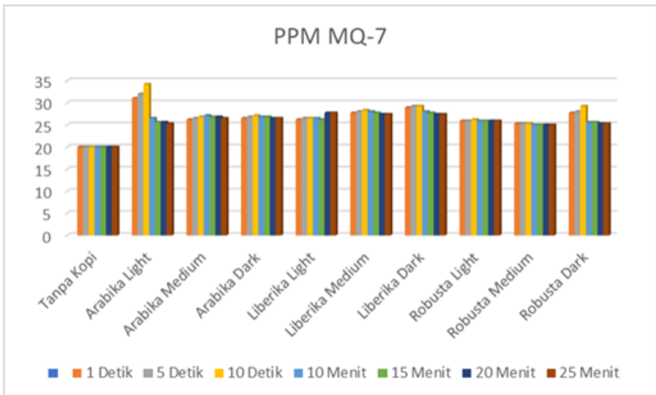
MQ-7 Sensor Respone

Measurement of the ADC value of the MQ-7 sensor against no coffee. arabica. liberica and robusta coffee can be seen in Picture 16.



Picture 16. MQ-7 Sensor ADC Value Graph

In the graph. it can be seen that the ADC value of the sensor without coffee is 100. Liberica coffee medium roasting level is the highest value in data collection when 10 minutes is 108. The response of Arabica coffee roasting light. medium. dark. Liberica coffee roasting light. dark and Robusta coffee roasting light and dark is from 92-104. The lowest ADC value is found in robusta coffee with a medium roasting level at data collection when 25 minutes is 91. Measurement of the PPM value of the MQ-7 sensor against no coffee. arabica. liberica and robusta coffee can be seen in Picture 17.



Picture 17. Graph of PPM Value of MQ-7 Sensor

In the graph. it can be seen that the PPM value of the sensor without coffee is 20. Arabica coffee roasting light level is the highest value in data collection when 10 seconds is 34.21. The response of Arabica coffee roasting medium. dark. Liberica coffee roasting light. medium. dark and Robusta coffee roasting light. dark is worth from 25.31-29.24. The lowest PPM value is found in robusta coffee with a medium roasting level at data collection when 10 minutes is 25.01. Measurement of the voltage value of the MQ-7 sensor against no coffee. arabica. liberica and robusta coffee can be seen in Table 4.

Table 4.MQ-7 Sensor Data Value Retrieval Table

Pengukuran	Tanpa Kopi	Arabika Light	Arabika Medium	Arabika Dark	Liberika Light	Liberika Medium	Liberika Dark	Robusta Light	Robusta Medium	Robusta Dark
1 Detik	0.47	0.47	0.47	0.47	0.46	0.49	0.51	0.47	0.45	0.44
5 Detik	0.47	0.47	0.47	0.47	0.47	0.50	0.51	0.48	0.45	0.45
10 Detik	0.47	0.47	0.47	0.47	0.48	0.50	0.51	0.47	0.46	0.44
10 Menit	0.47	0.46	0.47	0.47	0.47	0.51	0.5	0.47	0.45	0.44
Pengukuran	Tanpa Kopi	Arabika Light	Arabika Medium	Arabika Dark	Liberika Light	Liberika Medium	Liberika Dark	Robusta Light	Robusta Medium	Robusta Dark
15 Menit	0.47	0.46	0.47	0.47	0.45	0.49	0.5	0.47	0.45	0.44
20 Menit	0.47	0.46	0.46	0.47	0.45	0.49	0.5	0.47	0.45	0.44
25 Menit	0.47	0.46	0.46	0.46	0.45	0.48	0.5	0.47	0.45	0.43

Voltage testing using the formula from the data can be seen in equation 19 :

$$Tegangan = ADC \times \frac{Vref}{1023} \quad (19)$$

If the ADC value is 100 and Vref is 5 volts. the voltage value can be seen in equation 20 below :

$$Tegangan = 100 \times \frac{5}{1023} = 0{,}47\ volt \quad (20)$$

If the ADC value is 108 and Vref is 5 volts. the voltage value can be seen in equation 21 below :

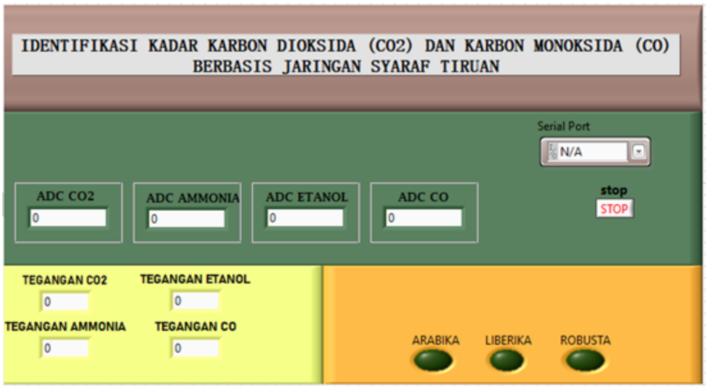
$$Tegangan = 108 \times \frac{5}{1023} = 0{,}52\ volt \quad (21)$$

If the ADC value is 91 and Vref is 5 volts. the voltage value can be seen in equation 22 below :

$$Tegangan = 91 \times \frac{5}{1023} = 0{,}43\ volt \quad (22)$$

Lab View Testing and Analysis

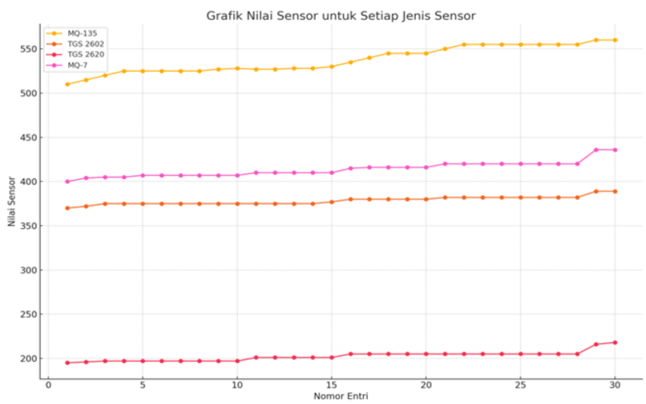
The gas monitoring process is carried out to see in real time the response of the aroma of coffee powder in the coffee powder storage container when there is coffee or no coffee. This monitoring process can be seen from the front panel on the labview in the section reading sensor adc data and sensor output voltage data which can be seen in Picture 18. below:



Picture 18. Front Panel

Testing Process

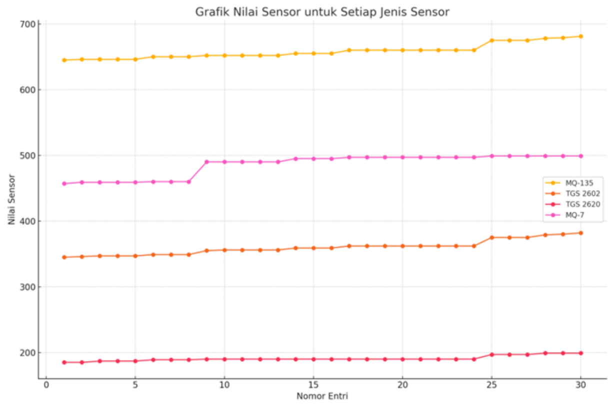
In the training sample data collection is carried out on three types of test gases such as robusta coffee. arabica coffee and liberica coffee. Sampling is done by taking 19 sample data from four sensors. as can be seen in the following figure. The test results were carried out with 3 kinds of coffee with 30 trials of each coffee. In Figure 19.20. 21 can be seen the results of the experiment below.



Picture 19. Arabika Coffee Testing Results

The graph above shows the sensor values for each sensor type (MQ-135. TGS 2602. TGS 2620. and MQ-7) by entry number. Each line shows the trend of each sensor throughout the 19 data entries. The following is an explanation of the graph:

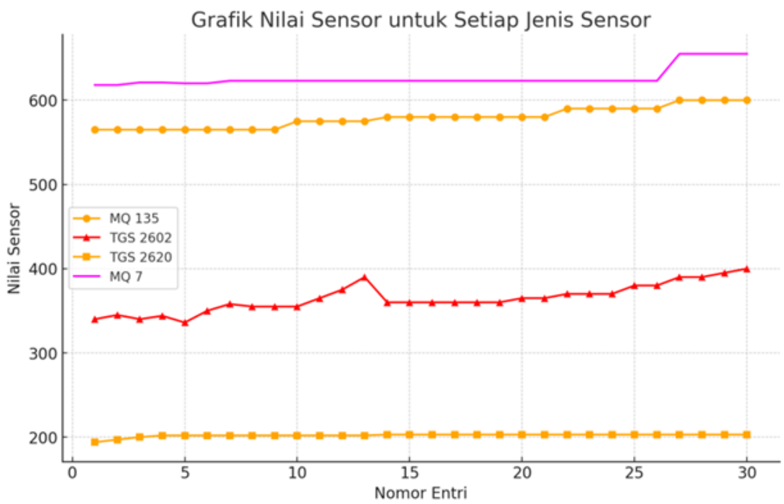
- MQ-135 (yellow) has the highest value which slightly increases with the entry number.
- TGS 2602 (orange) shows a steady increase in the lower value range.
- TGS 2620 (red) remains relatively constant with a slight increase in the last few entries.
- MQ-7 (pink) shows a more steady increasing trend compared to the other sensors.



Picture 20. Robusta Coffee Testing Results

The graph above displays the sensor values for each sensor type (MQ-135. TGS 2602. TGS 2620. and MQ-7) based on the entry number in the new table. The following is an analysis of the graph:

- MQ-135 (yellow) shows the highest value and increases slightly throughout the entry.
- TGS 2602 (orange) and TGS 2620 (red) are relatively stable with a slight increase.
- MQ-7 (pink) has small changes and stabilises at the beginning. then increases gradually until it reaches a higher value around the 9th entry.



Picture 21. Liberica Coffee Testing Results

The graph above shows the sensor values for each sensor type based on the data in the table. Each line shows the change in value of a different sensor (MQ 135. TGS 2602. TGS 2620. and MQ 7) according to the entry number.

CONCLUSIONS

Based on testing and data analysis. it can be concluded that the most gas found in coffee is carbon dioxide (CO_2). The highest levels of carbon dioxide (CO_2) and carbon monoxide (CO) were found in Arabica type coffee with a roasting light level with carbon dioxide gas levels of 389 ppm and carbon monoxide 34.21 ppm. The least carbon dioxide (CO_2) and carbon monoxide (CO) levels were found in Robusta type coffee with a dark roasting level with carbon dioxide gas levels of 327 ppm and carbon monoxide 25.31 ppm. The Artificial Neural Network method can identify Liberica coffee with a success rate of 98%. Arabica coffee 100% and Robusta coffee 98%.

FURTURE STUDY

This research still has limitations, so further research is needed related to the topic of Design of a Coffee Blending Device with Carbon Monoxide Levels (Co) Based on Backpropagation Artificial Neural Network 2 Hidden Layers in order to perfect this research and increase insight for readers.

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