

# IMPROVING MEAT EXPIRATION TIME PREDICTION USING THE INTERNET OF THINGS AND POLYNOMIAL REGRESSION

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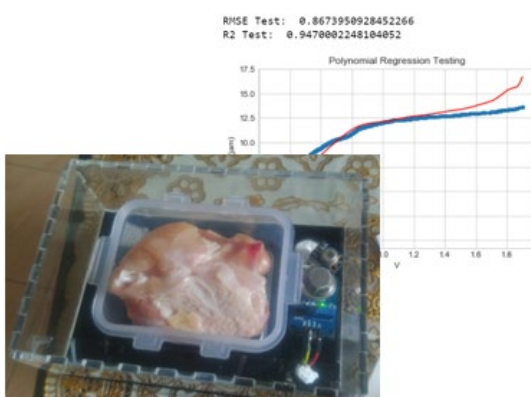
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## Graphical abstract



## Abstract

The meat's expiration time has a vital role for the consumer. Usually, the consumer will process the meat before the expiration time passes. However, most of the sellers in the traditional market did not put the expiration time. Even if it exists like in the modern market, the expiration time is determined by the Standard Operational and Procedure (SOP), which is that the meat must be sold within three days. Nevertheless, this expiration time determined by the SOP usually did not match with the meat's actual condition. Hence, the consumer usually misses to process meat and produce food waste. Therefore, this study proposed a device based on the IoT and Polynomial Regression to predict the meat's expiration time. The proposed device predicts the meat's expiration time based on the level of  $\text{NH}_3$  produced by the meat. The detected level of the  $\text{NH}_3$  will be sent to the server and is processed using the polynomial regression. The results can then be accessed using an Android application. From 30 sets of experiment data, the proposed device achieves 0.947 for data testing with an error of 0.18% and RMSE about 0.86.

**Keywords:** Food Waste, Expiration Date, Internet of Things, Gas Sensor MQ137, Polynomial Regression

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## 1.0 INTRODUCTION

It is undeniable that meat products provide essential nutrients, minerals, and vitamins for the human body. These are needed to keep the body healthy. The meat for the body comes from various sources, such as chicken, beef, and pork. For Indonesian people, chicken meat is one of the most consumed meat. According to data from the Organization for Economic Co-operation and Development (OECD), in 2018, chicken meat was consumed by 7 kg/capita [1]. In other conditions, beef consumption is only around 1.4 kg/capita. It shows that the amount of chicken consumption is far greater than beef consumption. It can be understood since the price of chicken meat is cheaper than beef. Also, chicken meat is easier to find

on the market because it does not depend on the season, such as fish or other seafood.

There is a period where the chicken meat is the best condition to be processed. The longer time chicken meat is in the open space, the meat's quality will decrease. In the end, the meat will be rot and not healthy to be consumed by the human and became food waste.

Food waste has become a severe issue in Indonesia. The Barilla Center for Food and Nutrition data shows that Indonesia ranks second in food waste per person each year. The data is supported by data from FAO, which shows that there are 13 million metric tons of wasted food every year, equal to the consumption of 11% of Indonesia's population, or about 28 million people annually [2]. Thus, it is essential to remind the consumer regarding the expiration time of the chicken meat

Indonesian people usually buy chicken meat in the traditional market. In this market, chicken meat is sold without packaging. Therefore, it is hard to find chicken meat's expiration time from the traditional market. On the other hand, it is easier to find chicken meat's expiration time since printed on the packaging. However, the expiration time has been given based on a predetermined Standard Operation Procedure (SOP). Sometimes, this expiration time is not accurate. So, the chicken meat may be rot faster or longer than the expiration time printed in the packaging. When the meat is being rotted faster, then it cannot be processed and becomes food waste. Thus, we need a system or device that can accurately predict the chicken meat's expiration time.

There is research conducted to detect meat freshness. The authors in [3] overview the research for chicken meat safety and quality evaluation using Hyperspectral Imaging (HSI). The HSI utilizes the method that combines the spectroscopy's main characteristics and the imaging technique to achieve fast and nondestructive testing. This technique shows great potential for detecting chicken meat's freshness. In this paper, the authors discuss the type of hardware and software used in the HIS system. However, the usage of the imaging technique may have bias results. Since the color may be different in different conditions, the result may vary and reduce the detection accuracy.

The authors in [4] develop the method to assess meat freshness using the integration of electronic nose (E-nose), Computer Vision, and Artificial Tactile Technologies. The proposed method tries to mimic humans' behavior when judging meat quality using his/her sensory function of smell, look, and touch. The authors process several parameters from each technique to determine the meat's quality. The result of their experiment was quite promising, with the root mean square error prediction (RMSEP) around 0.98 and the coefficient of determination (R2) around 0.94.

The authors in [5] have developed a system for detecting meat freshness using the smartphone. The authors use pork meat in their research. The proposed system uses the sensor to track CO<sub>2</sub> levels in the package associated with meat spoilage. The color of the used sensor will change depending on the quantity of bacteria present. The proposed system has a low cost with a total price of around 0.042€ and indicates it was already rotted.

The authors in [6] develop another method to detect the meat's freshness. The authors propose a novel paper-based pH-sensitive were coated with soybean hulls (SBH), bentonite, and bromocresol purple (BCP) as the meat detector. The authors change the wrapping paper to be the detector. The spoilage meat will have different pH and will change the color of the paper.

The study in [7] proposes a monitoring system for detecting meat's quality based on the smart RFID tag. The freshness of the meat is affected by the presence of microorganisms, bacteria, and gases. Therefore, this paper uses three sensors that detect the temperature, humidity, and gases released by meat. The proposed system collects the data and sends it to the server. The collected data will be compared with the meat storage environment to get the relationship between meat freshness and the sensor signal in the server. With this relationship, the proposed system can estimate the freshness of the meat. In this study, the authors use pork meat for the experiment.

This previous research has detected meat freshness successfully. However, the proposed method primarily detects meat freshness in real-time. The proposed methods did not provide information on the Date when the meat will be spoiled. So, they cannot be used to predict chicken meat's expiration date. A similar method with our study has been presented in [7]. The proposed device can predict the freshness of pork meat. However, they used the proposed method in the particular storage room to deliver the pork meat. Furthermore, the proposed system predicts the expiration time based on the datasheet. It cannot learn from the actual condition of the meat to predict the expiration time accurately.

Our study proposed a device that can predict the chicken meat expiration date used or bought by the household consumer. We design the device as compact as possible and utilize the polynomial regression method to improve the accuracy of meat expiration time prediction according to the meat's actual condition.

The proposed device is designed using an MQ137 gas sensor, where the sensor will detect ammonia gas (NH<sub>3</sub>) levels released by chicken meat. The device also uses NodeMCU ESP8266, which has a WiFi module to do the IoT (Internet of Things) function to send data to the Firebase cloud. We implement the polynomial regression method to predict the expiration time. We collect the data within 20 days as the training data for the polynomial regression method and uses the rest of seven days' data as the testing to calculate the accuracy of the prediction model. The prediction model obtained from the polynomial regression method will predict the expiration time based on the actual level of NH<sub>3</sub> released by chicken meat.

So, our study's contributions are as follows: (1) We proposed a device that can predict the meat's expiration time and (2) the implementation of the polynomial regression method to improve the accuracy of the meat expiration time prediction based on the actual condition of the meat. We also designed an Android-based application to provide the consumer's interface to monitor the expired time of their chicken meat.

## 2.0 MATERIALS AND METHODS

### Chicken Meat Expiration Process

Meat in this context is chicken meat, which is obtained from the traditional markets. In this study, we will make a prediction system for chicken meat expired time. Therefore, the authors define expiration as opposed to words from meat or foods that are still in good condition and edible. According to the Indonesian Ministry of Health, the criteria for foods that are still suitable for consumption are as follows [8]:

1. Being in the desired degree of maturity. (not being referenced because the meat is not cooked)
2. Free from pollution at each stage of production and subsequent handling.
3. Free from unwanted physical, chemical changes due to the effects of enzymes, microbial activity, rodents, insects, and damage due to pressure, cooking and drying.
4. Free from microorganisms and parasites that cause disease.

In points 3 and 4, meat suitable for consumption must be free from chemical changes originating from microbial, microorganisms, or parasitic activities.

According to Lawrie (1995), spoilage occurs in an open space (not in a container or wrapped). Microbes can enter the meat when the meat undergoes cutting until it is processed, and then the microbes will multiply [9]. Because meat contains rich protein, the microbes can break down the meat's protein into amino acids and polypeptides, known as deamination processes [10]. The deamination process will produce NH<sub>3</sub> gas. Thus, one of the main parameters used to detect meat rot is the ammonia gas (NH<sub>3</sub>) [11].

Generally, rotten meat can be determined by seeing physical changes, such as color or odor changes. However, color changes have a bias when used to automatically determine decay by using image processing because the color detected may be affected by light. Changes in odor are also challenging to automate because there are no sensors that can fulfill that. Therefore, knowing decay by detecting NH<sub>3</sub> gas levels is more straightforward than counting the number of microbes using a microscope. The usual way of determining the decay of the meat is using the Eber test and Postma test [12].

**Hardware Design**

The hardware in this meat expiration detection system consists of an NH<sub>3</sub> MQ137 gas sensor attached to the GPIO (General Purpose Input Output) pin of the NodeMCU ESP8266. An MLX90614 sensor is an ambient temperature sensor (Temperature around the object of detection) and an AM2302 humidity sensor. To get the timestamp of the collected data, Real-Time Clock is also installed on the hardware system. The power needed for this device is 3.3V, with 354 mA. The calculation of the power needed will be provided in the result chapter. Figure 1 shows how the hardware design has been made.

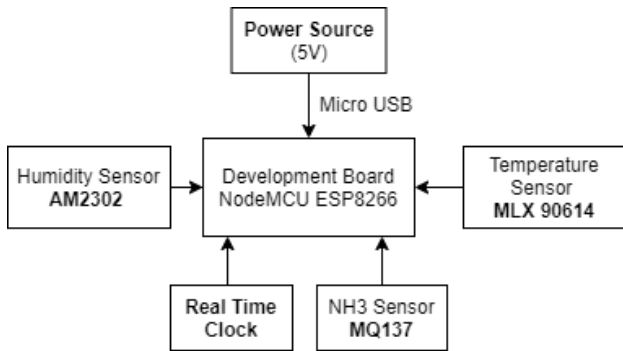


Figure 1 Hardware Block Diagram

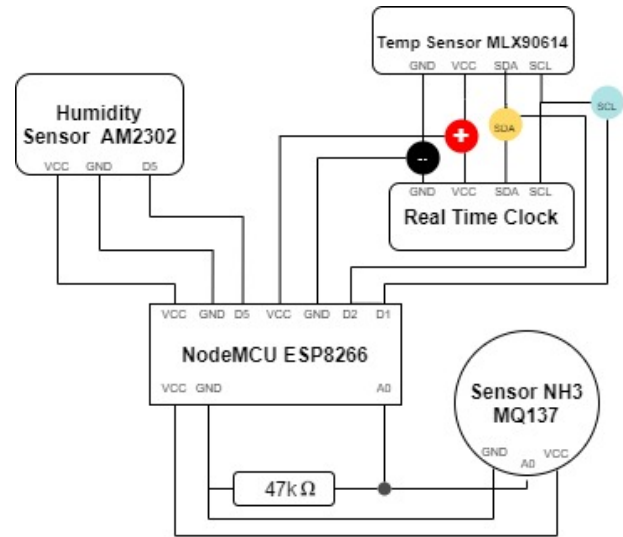


Figure 2 Wiring diagram

Initially, the system will detect NH<sub>3</sub> levels, temperature, and humidity through sensors connected to NodeMCU. The collected data is then combined with the time data obtained from the real-time clock and sent to Firebase. Determination of when the meat will rot is done in the software design section. The wiring diagram of the proposed system is depicted in figure 2. In the following subchapter, the sensors and hardware used by the device will be explained.

**NodeMCU ESP8266**

NodeMCU ESP8266 version 1.0 is a development board equipped with an on-chip system in the form of ESP-12E. We use version 1.0 because this version is the latest, and continued development of version 0.9 has been launched before. NodeMCU ESP8266 v1.0 is also equipped with a WiFi module that can be used to connect sensors or actuators attached to the pins they have. The pins owned by the development board consist of digital input pins, analog input pins, I2C pins consisting of data and clock, also VCC (power source), and ground pins. Also, NodeMCU has 4 MB of flash memory. This board uses a type B USB to connect with the PC. This connection is also used to program this board. In detail, the specifications of NodeMCU ESP8266 can be seen in table 1 [13]:

Table. 1: Specification of NodeMCU ESP8266

Specification	NodeMCU Version		
	0.9	1.0 (official)	1.0 (unofficial)
Vendor	Amica	Amica	Lolin
ESP Type	ESP12	ESP-12E	ESP-12E
GPIO Pin	11	13	13
ADC Pin	1 (10 bit)	1 (10 bit)	1 (10 bit)
USB to Serial Converter	CH340G	CP2102	CH340G
Power Input	5 Vdc	5 Vdc	5 Vdc
Size	47 x 31 mm	47 x 24 mm	57 x 30 mm

**MQ137 NH<sub>3</sub> Sensor**

The MQ137 gas sensor is a sensor made to detect CO, C<sub>2</sub>H<sub>6</sub>O, and NH<sub>3</sub> gas. This sensor works at a 3.3-5V DC voltage and has four legs on this sensor: VCC, GND, analog, and digital outputs. The conductivity of this sensor will change following the concentration of the gasses. Hence the sensor can be used to detect the decoy proses of the meat. This study takes analog values from this sensor; the voltage value is obtained from the gas detection results. The MQ137 datasheets [14] show that the voltage value is linear with the concentration gas value, although there is non-linearity of the sensor. However, the experiment conducted still shows a correlation between the collected variables. This non-linearity can be a topic that will be discussed in the following research.

**MLX90614 Temperature Sensor**

MLX90614 is an infrared-based temperature sensor for non-contact temperature measurement. A low noise amplifier, 17-bit ADC, and a powerful DSP to achieve high accuracy and resolution from the thermometer on this sensor. This temperature sensor is equipped with a digital SMBus output that gives full access to the measured temperature in a complete temperature range with a resolution of 0.02 ° C. This sensor has a type of I2C communication, relying on data transmission based on the clock. Therefore, four pins on the sensor must be connected to the development board: VCC, GND, SDA, and SCL. With this sensor, the temperature can be measured in the range of -40 ° C to 125 ° C for ambient temperatures and -70 ° C to 380 ° C for object temperatures, with an output resolution of 0.14 ° C [15]. This sensor's advantage is also real-time measurement without any delay. This sensor can also be said to be power efficient and has a relatively small size.

**AM2302 Humidity Sensor**

AM2302 is the cable version of the DHT22 humidity sensor in a larger plastic body (size 27mm x 59mm x 13.5mm). Capacitive humidity sensors and thermistors measure the surrounding air and produce a digital signal at the data pin. We only need to connect three pins to use this sensor: VCC, GND, and digital pin (DO). A 5.1K ohm resistor has also been installed, so it does not require an additional pull-up resistor [16].

In this study, a humidity sensor is used to find out how moist the observation area is. The moisture level will need to keep more than 50% because that condition is the perfect condition for bacteria to grow [7]. However, it does not directly affect the calculation in determining the meat's expiration time. The authors chose this sensor because it has better accuracy when compared to DHT11, which is 2-5%, with a price that is not much different. However, this sensor's weakness is that new data can only be obtained once every 2 seconds.

**Software Design**

The algorithm design for predicting chicken meat expiration time can be seen in the flowchart in Figure 3. The workflow of the software is as follows:

- A connection will be made between NodeMCU and the access point determined by the researcher and getting

internet access. When connected, the system can proceed to the next stage. Otherwise, the system will not start detection and continuously connect to the access point and the internet.

- The system initializes the sensors and the real-time clock used. Initialization is done by taking a delay of 60 seconds.
- After completing initialization, the sensors will detect. A real-time clock will also send a timestamp during detection.
- Data enters Firebase and can be seen the detected NH<sub>3</sub> levels
- Data on Firebase will also be connected to the Android application. On the Android application, there will be an expiration time calculation with the equation that has been obtained from the results of data processing. By only focusing on the value of the sensor output from Firebase, the tool will predict the expiration time of chicken meat and display it in the application.

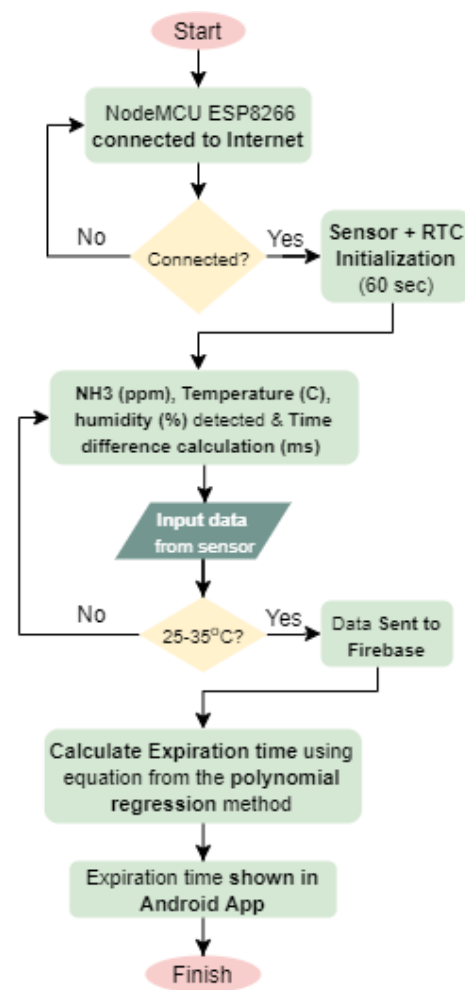


Figure 3 Flowchart of the proposed system

**Polynomial Regression**

Regression (Regression) is one method of machine learning (machine learning), which is a model that can be used to find patterns or relationships between related variables (Hosmer and Lemeshow, 2000) [17]. There are two types of variables in regression: the dependent variable (dependent) and the

independent variable (independent). From the variables in the regression, regression is divided into two types, namely linear regression and non-linear regression. Linear regression is when the variable is not an exponential variable, whereas non-linear regression occurs when it is an exponential variable (Hasan, 1999) [18].

In processing the data in this study, the regression used is non-linear regression and can be said to be a polynomial regression. We look for chicken meat's expiration time, which is the dependent variable or the variable *y* (response). In contrast, this study's independent variable (*x*) is the result of NH<sub>3</sub> sensor output (in mV). The relationship between the two variables is parabolic, so it is more suitable to use polynomial regression than linear regression.

Polynomial regression works by making a parabolic line pull, which predicts the desired data value. The following formula is used to predict variable *y*:

$$y_{\text{prediction}} = \beta_0 + \beta_1x + \beta_2x^2 + \dots + \beta_kx^k + \epsilon \tag{1}$$

The important thing of the polynomial regression method is an order (denoted by *k*) of the equation to determine the predicted value. The number of *k* can affect the accuracy of the predicted value of the dependent variable. Then, look for the value of beta ( $\beta$ ), which is the coefficient of the variable *x*.

Values  $\beta_1$  to  $\beta_k$  can be searched by installing a particular random value, which is then reduced by calculating alpha (learning rate) divided by the amount of data and multiplied by the amount of the difference between the predicted *y* and the detected *y* data. This calculation was formulated as follows:

$$\beta = \alpha \frac{1}{n} \sum_{i=1}^n (y_{\text{prediction}} - y) x \tag{2}$$

The number for learning rate is predetermined using the scikit learn library. Meanwhile, to find  $\beta_0$ , the method is similar to finding  $\beta$ , but not multiplied by *x*, but by 1 (one) only. To find the accuracy of this method, we implement the MSE (Mean Squared Error) calculation using a formula as follows:

$$MSE = \frac{1}{n} \sum_{i=1}^n (Y_i - \hat{Y}_i)^2 \tag{3}$$

Where *Y<sub>i</sub>* is the time variable value obtained from data collection,  $\hat{Y}_i$  is the predicted value, and *n* is the total amount of data. In another sense, MSE will show the magnitude of the deviation between the original data and the predicted data.

**Firestore Cloud**

Firestore is a no SQL database service developed by Google. Firestore is Backend-as-a-Service (BaaS), which is a backend cloud computing service. Thus, Firestore users do not need to manage the server. There are several services provided at Firestore, namely, analytics, cloud messaging, authentication, real-time databases, cloud storage, hosting, and even kits for machine learning [19]. In this study, we use only the real-time database feature that functions to store data in JSON. In order to store data in a database, there is a code for parsing data

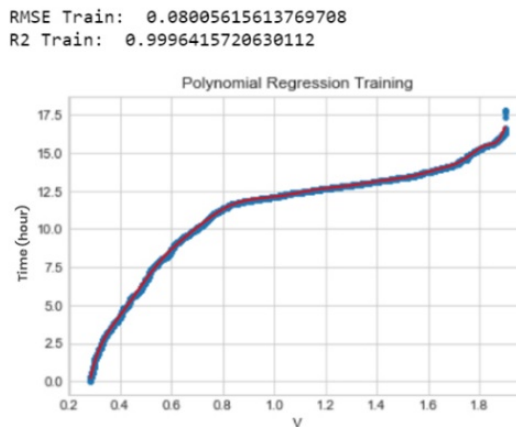
from Arduino. The key to sending data is the same token credentials to be precisely connected to the correct database. Also, data from Firestore can be taken (fetching) to an Android application using the API (Application Programming Interface) provided by Firestore.

**3.0 RESULTS AND DISCUSSION**

**Results**

This study has six data taken: temperature, humidity, NH<sub>3</sub>, sensor output, timestamp, and the time difference. This data is measured from the first time when the chicken meat is put on the proposed device. We are using a set of training data consists of 20 daily data from the data collection. This data shows 12,715 data lines with more spread when the sensor output is less than 1000 mV. This condition happens because increasing NH<sub>3</sub> gas in decay is an exponential process, with a not too fast rate at the beginning of decay. When approaching the threshold number (1000 mV), the decay rate will tend to be faster. This condition means that the increase in NH<sub>3</sub> numbers also becomes faster until it reaches a certain point (usually 2000 to 2500 mV). After passing a certain point, the rate of increase in NH<sub>3</sub> gas levels will slow down again. Thus, data processing to predict expiration time using a regression polynomial is entirely appropriate to be implemented in this study. The same characteristic is also found in testing data. From this data, it is known that there are 12,715 data lines.

From the training data, a prediction model can be made. Moreover, to confirm that the model is good enough to be used, the model will later be fitted with the testing data. The amount of RMSE and R2 can measure the variance which is occurred. The smaller amount of RMSE, the better result of the model. Vice versa, the more considerable amount of R2, the better result of the model. However, the amount of R2 cannot be more significant than 1. Figures 4 and Figure 5 below consist of the RMSE train, RMSE test, R2 train, R2 test, and the shape of the graph formed by training data and testing data. The author set the Y-axis as time because the author needs to know the expiration time based on the sensor output, which is the X-axis.



**Figure 4** RMSE, R2, and the graph of training data (blue) with the prediction model (red)

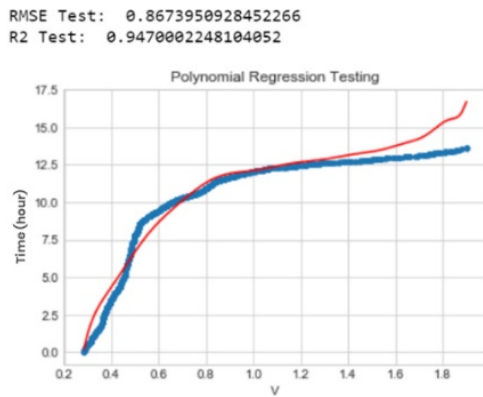


Figure 5 RMSE, R2, and the graph of testing data (blue) with the prediction model (red)

Discussion

This section will analyze the result conducted, the quantitative approach, and the data's qualitative approach. We are also going to calculate the power consumption needed for the device prototyped.

Data Interpretation

In this study, there are six data taken: temperature, humidity, NH3, sensor output (in mV), timestamp, and the time difference, measured from the first time the chicken is put on the device until the chicken rot.

Figure 4 shows the training data, which consists of 20 daily data from the data collection. This data shows 12,715 data lines with more spread when the sensor output is less than 1000 mV. It happens because increasing NH3 gas in decay is not a linear process but an exponential process, which is not too fast at the beginning of decay. When approaching the threshold number (1000 mV), the decay rate will tend to be faster. The increase in NH3 numbers also becomes faster until it reaches a certain point (usually in the numbers 2000 to 2500 mV). After passing a certain point, the increasing rate of NH3 gas levels will slow down again.

Moreover, the data obtained will be filtered to eliminate the noise of the data. When the noise has been removed, data can be processed by polynomial regression. Polynomial regression produces prediction lines that are almost like the graphs of the filtered data previously.

From the results of predictions, RMSE and R2 can also be calculated. RMSE and R2 are divided into RMSE, which is derived from training data and testing data. The RMSE training from the prediction results is 0.08, and the R2 is 0.9996. It indicates that the prediction result deviation that occurs is only 0.08 compared to the filtered data. Deviations in the results of the training data are arguably minimal. In addition, the R2 value that is close to 1 indicates that the prediction results are pretty reliable.

Meanwhile, the RMSE test result is 0.867, with R2 equal to 0.947. It indicates that when testing, the deviations that occur become larger, and performance predictions decrease. Even so, the performance when testing is not much different from the performance when training, so the system can be pretty good in predicting the decomposition of chicken meat. Graphs

of training data filtering results and testing data paired with predictive gradient lines can be seen in Figures 4 and 5.

Quantitative Interpretation

The focus of the quantitative interpretation is the accuracy of the device. The spoilage time resulting from the study will be compared with the spoilage time of chicken meat originating from reference paper, 12.029 hours, or 12 hours over 104 seconds [7]. The difference between the time of decomposition of chickens from the research results and the time of decomposition of chickens originating from the paper will later be calculated as the percentage of errors from this study.

The gradient of the prediction results can produce prediction models in the form of coefficient values (beta). As mentioned before, the degree chosen by the authors is 22. The number was chosen because it produces the smallest value of the deviation compared to other numbers. Equation 4 below is an equation to determine the expiration time.

$$\begin{aligned}
 \text{Time} = & -8,810x^{22} + 144,746x^{21} - 1,057,425x^{20} + 4,478,980x^{19} - 11,935x^{18} \\
 & + 19,907,701x^{17} - 17,928,908x^{16} + 854,699x^{15} + 15,868,090x^{14} \\
 & - 10,567,091x^{13} - 9,816,726x^{12} + 14,636,520x^{11} + 3,142,425x^{10} \\
 & - 16,065,172x^9 + 11,648,996x^7 - 18,370,007x^6 + 13,258,439x^5 \\
 & - 5,928,898x^4 + 1,741,939x^3 - 331,461x^2 + 37,510x^1 - 1,937.3 \quad (4)
 \end{aligned}$$

When the x in the equation above is 1 Volt (the threshold sensor value for chicken meat spoilage), it is found that chicken meat spoilage occurs when it is left up to 12.00759419 hours, or 12 hours 27 seconds. The 1 V figure is a decay rate of chicken meat based on reference paper [7]. In this study, the spoilage time is rounded to 12 hours because 27 seconds is slightly different and risky for decay. In equation (4), the author does not consider the temperature deviation since the purpose of measuring temperature is to keep the environment within the range of bacteria that can live and grow.

After getting the decay time based on the prediction results, an error calculation can be made from the reference paper's prediction results regarding the time of decay. The error calculation will be explained in equation five below.

$$\begin{aligned}
 \text{error} = & \frac{|\text{Spoilage time from reference} - \text{spoilage time from this study}|}{\text{Spoilage time from the reference}} \\
 = & \frac{12.029 - 12.00759419}{12.029} = 0.18\% \quad (5)
 \end{aligned}$$

Thus, the accuracy of this system is 99.82%.

The prediction equation for expiration time above is a reference for doing calculations, which will be performed on the Android application. The Android application will fetch data on the size of the sensor output from Firebase, and the data will be an x variable in the equation. The estimated expiration time will then be displayed, where the calculation results have been converted to hours and minutes. For example, if the result of the calculation is 7.8, the calculation of the time remaining until it expires is as follows:

$$\begin{aligned}
 &\text{Calculation result} = 7.8 \text{ hours} \\
 &\text{Time Remaining} = 12 \text{ hours} - 7.8 \text{ hours} \\
 &= 2.2 \text{ hours} \rightarrow \mathbf{2 \text{ hours}} \\
 &= 2.2 \text{ hours} - 2 \text{ hours} \\
 &= 0.2 \text{ hours} \times 60 \text{ minutes} \\
 &= \mathbf{12 \text{ minutes}}
 \end{aligned}
 \tag{6}$$

Thus, the calculation of chicken meat expiration is 7.8 hours or 7 hours 48 minutes, with the remaining expiration time is 2 hours 12 minutes. In the end, the application will display the remaining expiration time and can be known by the user easily.

On the Android application, the user can also know how safe the chicken meat is detected from the time remaining and from the safety, whether it is safe, nearly dangerous, dangerous, and expired. Those safety information categories are acquired from the paper that we referenced [7]. Figure 6 below will show the user interface of the Android Application.

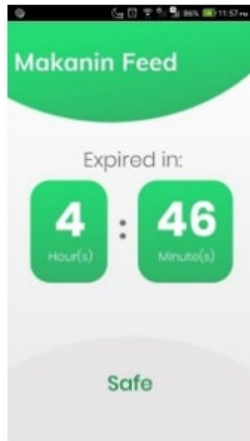


Figure 6a User interface when it is safe

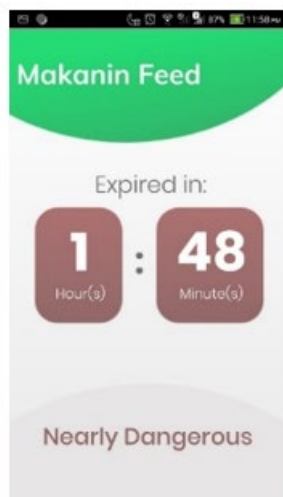


Figure 6b User interface when it is nearly dangerous

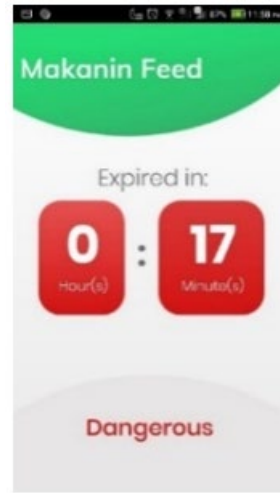


Figure 6c User interface when it is dangerous

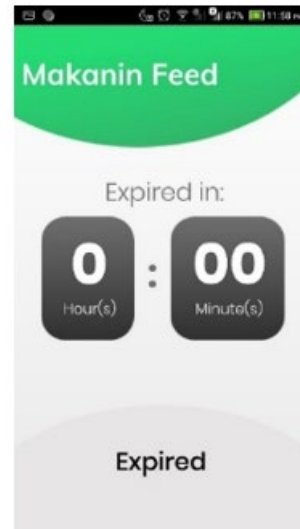


Figure 6d User interface when it is expired

**Qualitative Interpretation**

In order to ascertain whether the chicken was decomposed, organoleptic testing was conducted. The organoleptic test uses human senses to measure whether a product is safe to be consumed. This testing is widespread in the food and beverages industry. This testing method plays an essential role in quality control because the indication of spoilage can be known rapidly [20]. In organoleptic testing, the authors' parameters were chicken color changes, odor changes, and changes in texture or density. It also measured the pH of chickens because spoiled chicken's pH is alternating from acid to base.

Table 2 shows us that the chicken will change its pH to alkaline when it decomposes. Meanwhile, in general, the density of chickens will change from the previous springy or very springy (value 4 or 5) to soft (value 2 or 3). However, there was a slight anomaly in the chicken's texture on December 28 through January 8 data, which the texture did not change. In addition to the density, the chicken's smell will also change from being previously odorless or smelling only slightly (valued at 1 or 2) to bad smelly or very bad smelly (worth 4 or 5). The

meat color will also change when it decomposes, from light beige or pale beige (valued at 1 or 2) to brown or reddish-brown (worth 3 to 5). Therefore, the authors can conclude the decay from organoleptic testing by the difference in density, odor, color, and pH.

**Table 2** Organoleptic Testing Result

Date	pH		Density				Organoleptic Odor		Color		Output after expiration (mV)	In
	before	after	before	after	before	after	before	after				
21-Nov	acid	base	4	2	1	5	2	4	1050	melb		
26-Nov	acid	base	3	2	2	5	2	4	1420	melb		
27-Nov	acid	base	4	2	1	4	2	4	1360	melb		
28-Nov	acid	base	4	3	1	4	2	4	1430	melb		
02-Dec	acid	base	3	3	1	4	2	5	1190	melb		
03-Dec	acid	base	4	2	1	4	1	4	1920	melb		
04-Dec	acid	base	4	2	2	5	2	5	1760	melb		
05-Dec	acid	base	4	2	1	5	2	3	1012,9	melb		
08-Dec	acid	base	5	5	1	3	2	3	1060	melb		
10-Dec	acid	base	5	2	2	4	2	3	1040	before		
28-Dec	acid	base	5	5	1	3	2	3	1800	melb		
29-Dec	acid	base	5	5	1	3	2	4	1320	melb		
04-Jan	acid	base	4	4	1	3	2	2	1770	melb		
08-Jan	acid	base	4	4	1	4	2	3	1090	melb		
09-Jan	acid	base	4	2	1	5	2	3	1380	melb		
10-Jan	acid	base	4	3	1	4	2	3	1340	melb		
11-Jan	asan	base	4	2	1	5	2	5	1550	melb		
12-Jan	acid	base	4	2	1	5	2	5	1200	melb		
13-Jan	acid	base	4	2	1	5	2	5	1290	melb		
15-Jan	acid	base	4	2	1	5	2	5	1470	melb		
16-Jan	acid	base	4	2	1	5	2	5	1520	melb		
17-Jan	acid	base	4	2	1	5	2	5	1120	melb		
20-Jan	acid	base	5	3	1	4	2	3	1250	melb		
21-Jan	acid	base	5	2	1	4	1	5	1730	melb		
22-Jan	acid	base	5	2	1	4	1	5	1620	melb		
23-Jan	acid	base	5	3	1	4	1	3	1280	melb		
27-Jan	acid	base	5	3	1	4	2	3	1350	melb		
31-Jan	acid	base	5	2	1	4	2	5	1430	melb		
04-Feb	acid	base	5	2	2	4	3	4	1030	melb		
03-Mar	acid	base	5	2	1	4	2	4	1780	melb		

**Power Calculation**

This section will explain the power consumption of the chicken meat prediction device that has been made. This device has a power source that comes from a USB port owned by NodeMCU. The port is connected to a USB type B cable, which can then be connected to a power bank or directly to the electric socket by first being connected to a 5V power adapter. Following NodeMCU specifications, the power source for making the appliance turn on and work is a 5V power source. The device requires electricity with a power of 1.17 Watt (rounding 2 digits behind the comma) when the device is operating. The detailed power calculation will be explained in table 5 below

**Table 5** Power Consumption Calculation

Component	V(mV)	I (mA)	P (W)
NodeMCU ESP8266	3300	170	0.561
Sensor MQ137	3300	180	0.59400
Sensor AM2302	3300	1,5	0.00495
Sensor MLX90614	3300	2,5	0.00825
Real Time Clock	3300	0.0025	0.00001
<b>Total</b>		<b>354.0025</b>	<b>1.1682</b>

This tool has five main components: NodeMCU ESP8266, Ammonia gas sensor MQ137, AM2302 humidity sensor, temperature sensor MLX90614, and Real-Time Clock (RTC).

NodeMCU ES8266 has an output of 3.3 Volts, and with a current of 170 mA, the power consumption of this development board is 0.561 Watt. The MQ137 sensor has a power consumption of 0.594 Watt, while the AM2302 sensor has a minimal power consumption of 0.00495, and the MLX90614 temperature sensor has a power consumption of 0.00825, and the RTC has a power of 0.00001.

With a power consumption of 1.17 Watt, this tool can work for 14.12 hours or 14 hours 7 minutes continuously if the power bank has a 5,000 mAh (minimum power bank capacity sold in the market). According to trials conducted by researchers, the detection of chicken meat once takes 1.5 minutes. If it is assumed that this tool's user performs one-time detection of chicken meat for 1.5 minutes, this tool can perform 564 measurements until the capacity of the power bank is used up. Therefore, it was concluded that the durability of using expired chicken meat prediction has efficient and efficient power consumption.

**4.0 CONCLUSION**

We have presented our proposed device to predict the chicken meat expiration time. The experiment has shown that the proposed device was successfully created and can predict the expiration time accurately. The results of data processing using the polynomial regression method are suitable to be implemented in this chicken meat expiration tool because it only produces an error of 0.18%, with an RMSE train of 0.08 and an RMSE test of 0.86. The system's reliability also showed promising results, with the R2 train value of 0.9996 and the R2 test of 0.947. The power consumption calculation results indicate that the power consumption of the proposed device consumes 1.17 Watts. With a power bank capacity of 5000 mAh, the proposed device can perform 564 times of detection, and each detection will be held for 1.5 minutes.

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