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Original Article

Design and Development of an Electronic Nose as a Tool for Detecting the Aroma Quality of Pandanwangi Rice

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Abstract

Pandanwangi rice, a local aromatic variety originating from Cianjur Regency, has a distinctive pandan aroma due to the presence of the amino acid derivative compound phenylalanine, specifically 2-acetyl-1-pyrroline. Distinguishing the aroma of Pandanwangi rice is the key to identification. Electronic Nose (e-nose) technology, which is known for its ability to distinguish aromas emitted by organic materials, is an important tool in this research. The main objective of this research is to determine the design technique for an electronic nose tool, evaluate the effectiveness of the electronic nose in detecting and distinguishing the aroma of Pandanwangi rice. Descriptive analysis was carried out using Pandanwangi rice samples originating from various districts including Warungkondang, Gekbrong, Cianjur, Campaka, Cugenang, and Cibeber, as well as Sintanur rice (positive control) and IR64 (negative control). The research results show that the designed tool has the potential to detect the aroma of Pandanwangi rice quickly. In addition, the results of aroma detection using an electronic nose tool showed variations in the concentration of volatile compounds found in Pandanwangi rice. Pandanwangi rice from Cibeber District had the highest concentration of volatile compounds, while rice from Campaka District had the lowest concentration of volatile compounds.Even Sintanur rice, which is famous for its similarity and is often mistaken by the general public for Pandanwangi rice, did not receive a significant response from the censors.

Keywords: *Aroma, E-nose, Pandanwangi and MQ-2 Sensor.*

Introduction

Food is closely related to human life. As time goes by, human needs for food have changed drastically. People are increasingly paying attention to food safety, health, composition, brands, origins and processing methods, which of course cannot be separated from food testing technology. (Wang & Chen, 2024). Pandanwangi rice is an aromatic rice variety classified as javanica (sticky rice), characterized by the aroma of pandan and soft texture, and is a superior food crop commodity in Cianjur Regency(MP3C, 2015). The local superior rice variety Pandanwangi is suitable for planting in the medium highlands at an altitude of approximately 700 meters above sea level. This type of rice has long been known and cultivated by farmers around the foot of Mount Gede, especially in the Warungkondang, Gekbrong, Cugenang, Cianjur Kota, Cilaku, Cibeber and Cempaka areas. This area is the center for the preservation and development of Pandanwangi rice production (DISPERTA, 2017) . The aroma active compounds in rice are key elements that determine its quality and freshness characteristics. (Rahimzadeh *et al*., 2022). Genuine Pandanwangi rice is characterized by large grains with a white mark in the middle. The unique aroma of pandan in Pandanwangi rice is caused by the presence of the amino acid derivative compound phenylalanine, especially 2-acetyl-1-pyrroline (Mihrani *et al*., 2022). Another problem encountered in the field is the scarce stock of genuine

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Pandanwangi rice on the market. This is because farmers prefer to cultivate rice varieties which have a shorter harvest period compared to Pandanwangi rice which has a harvest period of 155 days (± 6 months). This is also the trigger for the proliferation of fake Pandanwangi rice on the market which is sold at a much cheaper price than genuine Pandanwangi rice. Fake Pandanwangi rice is usually mixed with other, cheaper rice.

One way to differentiate between real and fake Pandanwangi rice is to differentiate its aroma. Accurate determination and evaluation of odor in rice requires identification of the substances that influence the odor along with the development of methods to determine their amounts(Rasooli & Khorramifar, 2022). Electronic Nose (e-nose) technology is known to be able to distinguish the aromas emitted by organic substances. Some examples of applications include aroma testing for coffee, tea, chocolate and other strong aromas. The electronic nose also functions as an alternative instrument solution that is easy to use, versatile, and relatively cheap for testing the aroma of cooking oil (Putra *et al*., 2015). Electronic noses for tracking environmental odors have evolved significantly over the past twenty years, ranging from experimental devices to useful tools used by industrial plant operators and municipal government agencies (Caray *et al*., 2024). This electronic device is powerful, useful and fast, and can be used to aid in gas chromatography and sensory evaluation. (Barea-Ramos *et al*., 2023).

Research regarding the use of an e-nose as a means of detecting the aroma of Pandanwangi rice has never been carried out before. Based on this, research was carried out to differentiate the aroma of Pandanwangi rice from seven geographically located districts from other rice varieties.

Materials and Methods

Location and Time Research

This research was carried out from February 2022 to July 2022 starting from preparation, data collection and analysis, and writing a report. The research location is in the food analysis and processing laboratory, Faculty of Applied Sciences, Suryakancana University.

Tools and materials:

The tools used in this research were the MQ-2 sensor, electric stove, Node MCU, ESP 8266, jumper cables, USB cables, laptop and writing equipment. Meanwhile, the materials used in this research were pandanwangi rice, sintanur rice and IR 64 rice.

Research Stages

Tool Design:

Designing a Rice Aroma Detector Device, in this circuit the sensor input is connected to the NodeMCU, namely the sensor reading data that enters the microcontroller will be processed and calibrated. The Vcc pin of the MQ 2 sensor is connected to the 3V pin of the tool system. The Gnd pin on the MQ 2 sensor is connected to the Gnd pin on the tool system. Pin A0 of the MQ 2 sensor is connected to pin A0 of the tool system. Meanwhile, the MQ 2 Output Pin is connected to the NodeMCU pin.

Arduino, this circuit functions as the control center for the entire existing system. The main component of this circuit is the Arduino microcontroller IC no . All programs are loaded into memory

MQ-2 Sensor Series, this circuit functions to receive gas coming out of Pandanwangi rice in the form of volatile compounds. The main component of this series is the MQ-2 sensor. Overall Design *of the E-nose Sensor*, the sensor system for detecting the type of rice is designed using the MQ 2 gas sensor.

Experimental design

This research uses descriptive analysis, the data that will be used is data from the detection results of the design of the Pandanwangi rice aroma detection tool. In this study the rice samples were as follows:

P1 = Cibeber Pandanwangi Rice
P2 = Cilaku Pandanwangi Rice
P3 = Pandanwangi Cugenang Rice
P4 = Cianjur Pandanwangi Rice

P5 = Pandanwangi Campaka Rice
P6 = Nasi Warung Kondang Pandanwangi
P7 = Pandanwangi Gekbrong Rice
P8 = Sintanur Rice (positive control)
P9 = Rice IR 64 (negative control)

Data collection technique

The data collection method includes distinguishing between aromatic rice, non-aromatic rice and pure Pandanwangi rice. This classification is based on observational parameters, specifically focusing on aroma.

Data analysis technique

The conclusions from the device detection design can be known directly via *the Thingspeak server* which is displayed on the laptop in the form of graphs and numbers processed using Minitab (*contour plot*).

Results and Discussion

The electronic nose consists of three main components: the MQ-2 sensor (data input), the MCU node (processing), and the laptop (data output). Figure 1 illustrates the workflow of the electronic nose system under construction. The initial component, namely the MQ-2 Sensor, functions as an aroma detector. This device is capable of detecting various types of gases, including LPG (Liquefied Petroleum Gas), alcohol, smoke, methane, propane and carbon monoxide. (Suryana, 2021) , making it versatile for various detection applications.

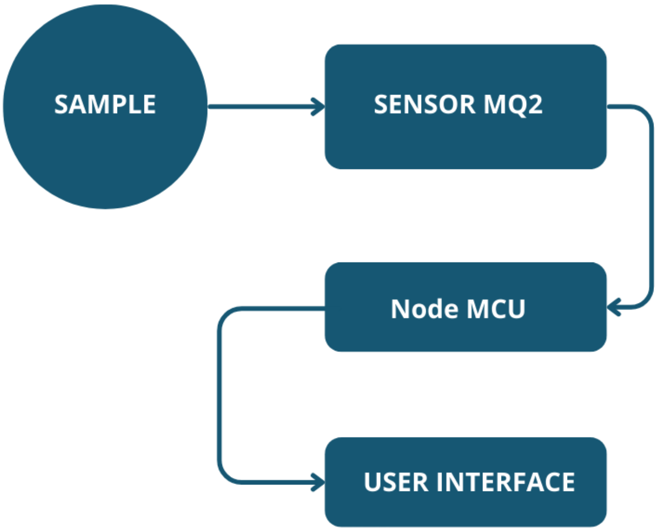

Figure 1 Flowchart for Designing Aroma Detection Equipment

LPG, or Liquefied Petroleum Gas, undergoes a transformation into liquid form due to increasing pressure and decreasing temperature. However, under certain atmospheric conditions, LPG remains in gas form. This gas consists mostly of propane (C_3H_8) and butane (C_4H_{10}), accompanied by small amounts of other hydrocarbons, including ethane (C_2H_6) and pentane (C_5H_{12}) (Ritonga, 2021).

Alcohol is an organic compound that has a hydroxyl group (-OH) attached to a carbon atom (which is also bonded to a hydrogen atom and/or other carbon atoms. Carbon monoxide (CO) is a colorless, odorless and tasteless gas. Gas This is produced from incomplete combustion of carbon compounds (generally in internal combustion engines).

Methane (CH_4) is an odorless, colorless and non-metallic gas, but the smell of sulfur can be added to detect if a leak occurs. Meanwhile, propane (C_3H_8) is a three-carbon alkane compound which is in gas form, but can be compressed into a liquid for distribution purposes. This gas is used as engine fuel and as a mixture of LPG. This gas is also odorless, so ethanethiol is generally added so that it can be detected if a leak occurs (Peris & Gilabert, 2009) .

E -nose not only has the advantages of simple operation and fast recognition ability, but also can carry out on-site and real-time online monitoring (Chen *et al*., 2023). Smell machines can recognize the composition of a fragrance by estimating its concentration or determining some of its intrinsic properties, which is difficult for the human nose. In general, the human olfactory system is a five-step process that includes smelling, scent reception, evaluation, detection, and elimination of scent effects. (Afkari *et al*., 2023).

In this research, the MQ-2 sensor was used to detect gas containing volatile compounds in Pandanwangi rice. This sensor functions to detect the volatile compound 2AP found in Pandanwangi rice which comes out from heating the rice. The MQ-2 gas sensor is made from SnO2 semiconductor material which has low conductivity in clean air, whereas if the sensor detects the presence of gas, the sensor conductivity will be higher. The increase in gas sensor conductivity is linear with increasing gas concentration (Hadi & Adil, 2019).

This sensor has two layers of *fine mesh made from stainless steel* (anti-explosion mesh) so that only gas can enter the *sensor chamber* (detection). After the detection process by the MQ-2 sensor, the next process is translating the 2AP volatile compound gas into graphic data and numbers on the MCU Node. The MCU node (second part) acts as a storage tool for programs that have been created and becomes a tool for translating the results from the MQ-2 sensor in steam form into data in the form of numbers using an internet connection *as a database.*This process requires a short time so that the data displayed is *real time* (direct) data. The use of I oT (*Internet of Things*) technology can facilitate various kinds of work, including in the agricultural sector (Setiawan *et al*., 2018).

The final part is that the laptop acts as a tool to display data translated by the Node MCU. This data can determine the quality and authenticity of products electronically because it can be done quickly, automatically and objectively and can be carried out as a product evaluation in the context of quality assurance (Siddiq *et al*., 2021).

Electronic Nose Testing for Pandanwangi Rice Aroma Detection

The sensor scheme or workflow relies on three main components: the detection process (input), the translation process (processing), and the data display (output). This sequence can be observed in the attached image (Figure 2).

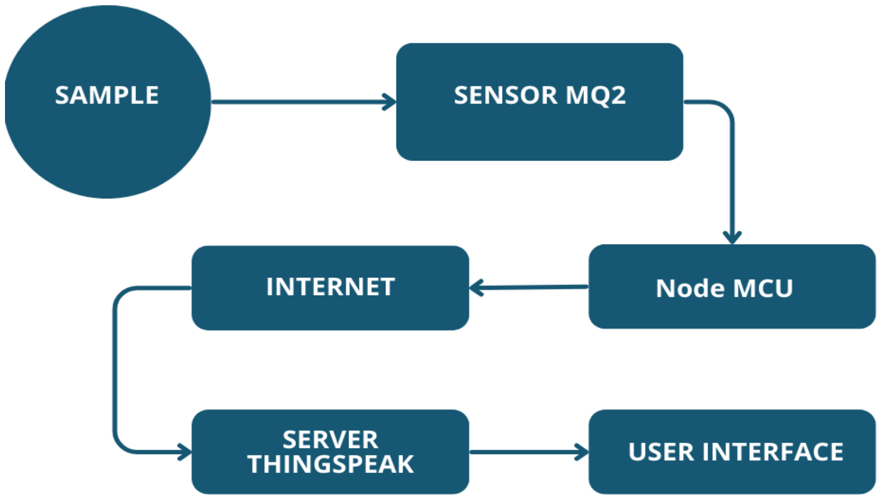

Figure2 Sensor Working Scheme

Each sensor in the E-nose reacts to odorous and odorless volatile compounds, producing individual patterns known as “odor prints.” This sensor can be applied to any product that re-releases volatile compounds within the sensitivity range of the sensor. (Zhou *et al*., 2021) .The processed rice is then put into an Erlenmeyer flask containing the MQ-2 sensor. Roasting time must be controlled precisely because it produces different levels of roasting, ranging from very light to very dark colors and affects the resulting aroma. (Cascos *et al*., 2024) . Next, the sensor detects the aroma emitted along with the steam (Figure 3). This aroma can be felt by the sensor when the rice reaches a temperature range of 65-95ºC, exactly for 180 seconds, as programmed in the Arduino ESP8266 code and the MCU node which acts as a logical gate. The duration of 1-180 seconds, during which volatile compounds are detected, is called the steady-state period. During this period, the output data displays a value of 0 which indicates the absence of volatile compounds in the sensor container (Lelono & Chairiawan, 2013). In addition, the steady state period corresponds to the duration required for the product to heat up, as the sensor is only able to detect the aroma when the product emits hot steam containing volatile compounds. (Siddiq *et al*., 2021).

Figure 3. Pandanwangi Rice Aroma Detection Device Series (Private Documentation, 2022) .

During *the sensoring process,* the MQ-2 sensor response to rice can change according to the detected gas concentration value (Suryana, 2021) . When the gas concentration value is high or the temperature is more than 95ºC, the sensor no longer detects volatile compounds but other gases. Therefore, heating must be less than 95ºC so that the concentration value or output data in the form of a graph is the concentration value of the volatile compound 2AP (Sari, 2018) .
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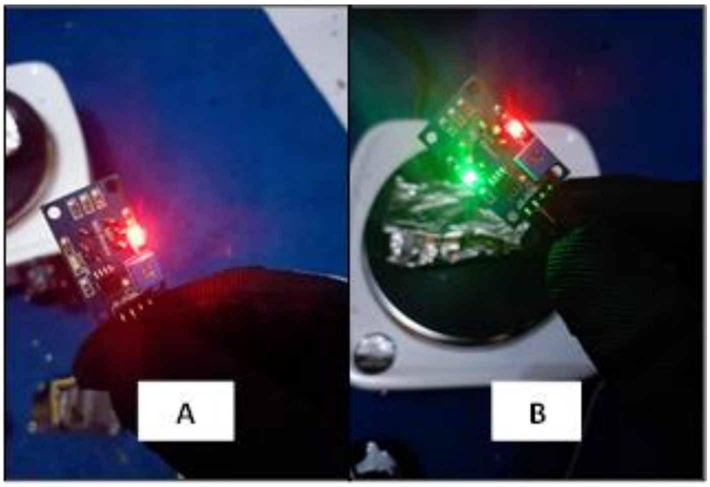

Figure 4 Indicators of volatile compounds detected by MQ-2(Personal Documentation) .
A: the sensor does not detect 2AP volatile compounds and B: the sensor detects 2AP volatile compounds

The detected aroma is then translated by the MCU Node which contains the code. This coding will detect the concentration level of the 2AP volatile compound which can be detected by the MQ-2 sensor (Figure 4). This process takes place right away (*real time*), so the design of this tool can be used to detect the aroma of rice quickly (*rapid*).

The data displayed on the laptop screen is in the form of graphs on *the Thingspeak server* and numbers in Microsoft Excel. In this process, it can be seen which rice products have the most concentrated/strongest 2AP volatile compounds and which ones have a lower concentration or even have no volatile compounds (Table1). This shows that the Pandanwangi rice aroma detection tool has the most optimal value for Pandanwangi rice ranging from 10 to 67 with a heating time of 3 minutes from 65ºC to 95ºC (Figure 5) and it is proven that this tool has the potential to detect rice. the aroma of Pandanwangi rice.

Table1 Aroma Detection Results of Pandanwangi Rice

NO	Type/Origin of Rice	Detection Results	
		Sent	Not detected
1	Warung Kondang	✓	
2	Gekbrong	✓	
3	Cianjur	✓	
4	Puddle	✓	
5	Kampaca	✓	
6	Cibeber	✓	
7	Sintanur (positive control)	✓	
8	IR64 (negative control)		✓

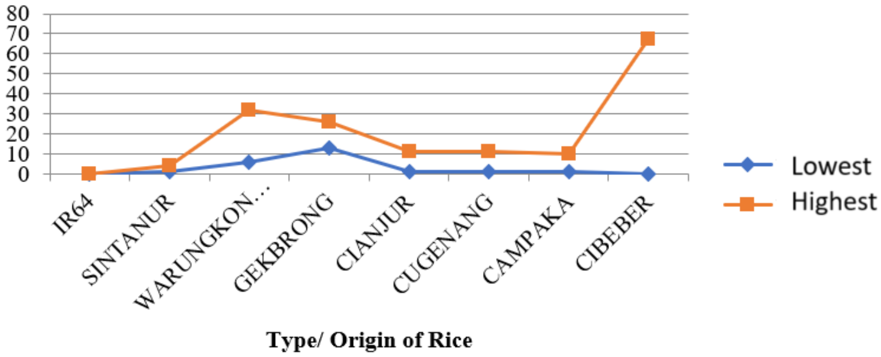

Figure 5 Results of detection of the volatile compound 2AP

Electronic Nose Test to Distinguish the Aroma of Pandanwangi Rice

The results of the Pandanwang i rice aroma detection showed that the Pandanwangi rice sample from Cibeber District was the rice that produced the strongest 2AP volatile compounds, while the sample from Campaka District was the rice with the weakest 2AP volatile compounds.

aroma detection result data is displayed on the laptop screen in the form of graphs on *the Thingspeak* server and numbers on Microsoft Excel , processed using Diminitab to obtain *a contour plot* to make it easier to read the rice aroma detection result data (Figure 6) .

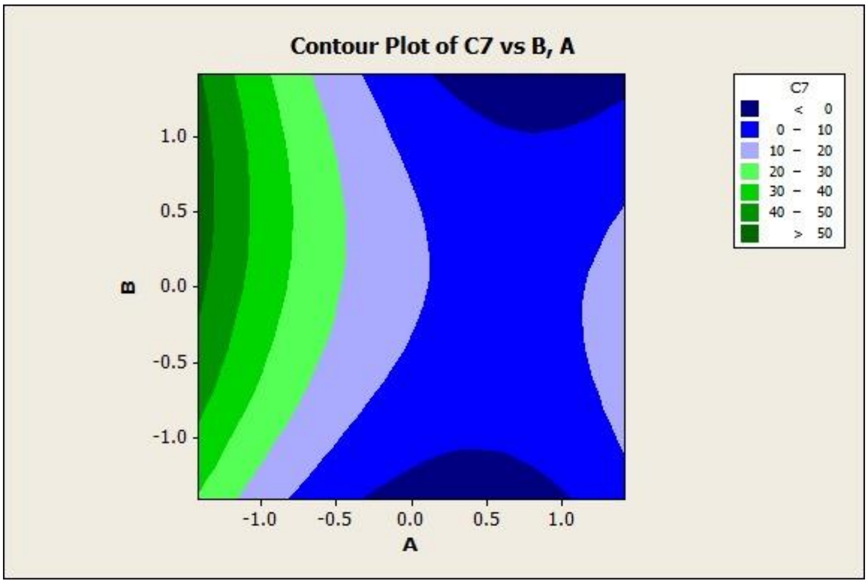

Figure 6 Reading graphs using Minitab (Contour Plot)

The graph above shows data on volatile compounds released from rice, where rice with a value of 0 - 10 is IR 64 rice and Sintanur rice, where this rice only emits very low volatile compounds, while rice with a value of 10 - 50 is Pandanwangi rice. which has higher volatile compounds than other rice which is used as a negative control and positive control.

The graph presented shows that Pandanwangi rice from Cibeber District has the highest concentration of volatile compounds compared to rice from other districts. These differences are likely due to environmental and cultivation factors, as well as genetic influences, which impact the aroma profile. As noted by Pachauri *et al*. (2010), unique formation reactions in rice plants depend on ecological variables and agricultural practices. Meanwhile, Pandanwangi rice in Cibeber District is cultivated in areas with minimal residential development so the water sources are relatively cleaner and more abundant. Ren *et al*. (2017) also suggested an interaction between nitrogen levels and irrigation practices in 2AP biosynthesiscompounds, further supporting the idea that environmental conditions play an important role in aroma development (Mo *et al.* 2019) .

Rice with the lowest 2AP volatile compound content is found in Cianjur Regency, followed by Cugenang District, and Campaka District. This is believed to be the reason for the lack of detectable volatile compounds. In contrast, in Cianjur Regency, higher temperatures are thought to have contributed to reduced levels of the volatile compound 2AP. This finding is supported by Itani *et al* (2004) noted that long harvest times and exposure to high temperatures can cause reduced 2AP concentrations. In Campaka District, Pandanwangi rice has the lowest levels of volatile compounds compared to other districts, this is thought to be caused by improper post-harvest handling . Trihaditia & Puspitasari (2020) depicts to preserve the 2AP compound content, especially in aromatic rice grains such as Pandanwangi, it is necessary to store them in panicle form. However, in Campaka District, panicles that have been separated are stored for more than 2 days before being milled.

Conclusion

An electronic nose has been designed that utilizes the MQ-2 Sensor as a tool to detect the aroma and volatile compound 2AP in Pandanwangi rice. This electronic nose is able to quickly detect volatile compounds and recognize differences in the concentration of the volatile compound 2AP contained in Pandanwangi rice. The detection results achieved through the electronic nose enable the differentiation of the aroma of Pandanwangi rice between sub-districts, with a numerical range from 10-50, in contrast to other rice varieties, which are usually in the numerical range 0-10. In particular, Cibeber Regency has the highest and lowest concentrations of 2AP volatile compounds, and Campaka District has the lowest concentrations of 2AP volatile compounds. Even Sintanur rice, which is famous for its similarity and is often mistaken by the general public for Pandanwangi rice, did not receive a significant response from the censors.

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Conflict of Interest

Nil.

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