Detection of the cooking oil aroma by using a gas sensor in an electronic nose system

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Abstract. Cooking oil is a food ingredient that is widely used for frying food. When cooking oil is used over and over again, cooking oil becomes dangerous for consumption. In general, cooking oil that is widely used by the community is simple-packaged cooking oil and bulk cooking oil. The design of a cooking oil aroma detector is conducted to distinguish the aromas of cooking oil that is consumed by the community. This tool is made by using the TGS2611 gas sensor as an electronic nose system. The electronic nose system can detect the aroma of cooking oil through the air. The aroma stimulus captured by the sensor array is a signal response that increases the electric voltage. The average output voltage of the gas sensor produced is 172.3 mV, 204.8 mV, and 181.4 mV for samples of simple-packaged cooking oil, bulk cooking oil, and used cooking oil, respectively. These results indicate that bulk cooking oil has the highest response. While the simple-packaged cooking oil has the lowest one.

1. Introduction
Electronic Nose (e-nose) is a technology whose development and application are still very broad today. The e-nose is an instrument whose work imitates the working principle of the sense of smell. The e-nose consists of an array of gas sensors in place of olfactory receptors that function to detect odors or aromas. The aroma that is detected by several gas sensors will then form a certain pattern. This pattern will then be recognized using a pattern recognition system.

The use of the e-nose system has been widely used in various fields. For example: in the fisheries sector. Lintang et al. (2016) has successfully detected the scent of freshwater fish using the e-nose system. The sensor in this system is designed to flow air from the sample room to the sensor room using a fan. During the scent sampling process, the fan will flow the air containing the aroma sample from the sample room to the sensor room. The aroma stimulus captured by the sensor array in the form of a signal response was extracted by the integral method to obtain a digital sample scent pattern. This pattern is then analyzed using the PCA (Principal Component Analysis) method to determine the aroma pattern of freshwater fish [1].

In the food sector, several studies have been carried out, namely: testing the composition and properties of coffee, tea, chocolate, and other pungent aromas. It is also associated with sensory properties and classification based on the level of sample quality. Lelono and Chairiwawan (2013) use the e-nose system to identify the smell of snakefruit [2]. Snakefruit is identical to its pungent smell. However, detecting or smelling the aroma of snakefruit is not as easy as imagined. The human nose
will not always be consistent in carrying out its duties because it depends on human feelings and health itself. This greatly affects humans in identifying an odor, such as the smell of snakefruit.

Nasir (2016) can recognize and detect odors in tofu containing formaldehyde and fresh tofu by using gas sensors MQ5, MQ6, and MQ138 [3]. This sensor can respond to the development of the aroma of tofu with formalin and without formalin because it is sensitive to the volatile compounds present in both samples. The MQ138 sensor is the most sensitive sensor for volatile compounds. Sudarmaji and Ediati (2011) designed an e-nose system to identify the ripeness of tropical fruit using the SnO₂ semiconductor gas sensor. There are 5 sensors used, namely TGS2600, TGS2602, TGS813, TGS2611, and TGS2612. Identification using the artificial neural network method on the output signal pattern of the sensor series is used to determine the level of fruit maturity. The measurement results of the sensor series were correlated with physicochemical parameters (moisture content, sugar content, and vitamin C) as an indicator of fruit maturity [4].

The use of the e-nose system can also be used to detect alcohol in perfume [5], to detect the breast cancer through urine [6], to distinguish the aroma and type of teak and mahogany wood [7], to detect hydrocarbon compounds in premium oil [8], to detect the basal stem rot of palm oil [9], to detect the aroma of robusta coffee [10] and many more. E-nose is an alternative solution for an aroma test instrument that is easy to use, versatile, and relatively inexpensive [11].

Today, the e-nose is used for quality control applications in the food, beverage, cosmetic, biotech, medical and environmental protection industries. In the food industry, the e-nose has been used to detect the freshness of foods such as meat and other fermented foods. One of the food ingredients that are consumed by many people is cooking oil. Cooking oil is a food ingredient with the main composition of triglycerides which comes from vegetable ingredients through a refining process that can be used for frying. Cooking oil is one of the basic needs of the community in meeting the needs of daily life. Cooking oil consumed daily is closely related to health.

There are two types of cooking oil, namely, bulk cooking oil and small-packaged cooking oil. Heating cooking oil at high temperatures, and using it repeatedly, will cause the oil to be damaged due to oxidation which can produce aldehyde, ketone, and aromatic compounds that have a rancid or unpleasant odor. Besides, it can result in the polymerization of unsaturated fatty acids, so that the composition of the oil medium changes. Therefore cooking oil also has limitations in terms of oil quality. For this reason, this study uses an e-nose system to distinguish the aroma of cooking oil. There are three cooking oils used as samples, namely simple-packaged cooking oil, bulk cooking oil, and used cooking oil.

2. Experimental Method
In this study, the equipment components used were a 12 V adaptor, TGS2611 gas sensor, arduino nano microcontroller, LCD, DC fan, and potentiometer. While the samples tested were simple-packaged cooking oil, bulk cooking oil, and used cooking oil. The block diagram for measuring the sample output voltage can be seen in figure 1.

The adaptor functions as an AC to DC power converter for the energy supply of electrical power to the e-nose system. The TGS2611 gas sensor functions as an input signal receiver and data transmitter. The arduino nano functions as a receiver, data processor, and system controller. The results of the data in the form of electrical voltage are displayed on the LCD. DC fan as odor spreader and normalize the sensor room. While the potentiometer functions as a regulator of the brightness level on the LCD. The measurement system configuration to detect the difference in sample voltage can be seen in figure 2.

Figure 2 shows that the TGS2611 gas sensor is connected to pin 12 of the arduino nano microcontroller, the LCD is attached to pins 5, 6, 7, 8, 10, and 11, the 12 V adaptor is connected to the 5V and GND pins and the potentiometer is connected to the CONTR LCD pin [12]. This system is then assembled in a chamber which consists of two chambers. The first chamber uses as a sample room and the other as a sensor room. While DC fan located between these chambers (figure 3).
Figure 1. The block diagram of the measurement system.

Figure 2. The system configuration of cooking oil aroma detection.

To get the voltage value of each sample, first record the sensor output voltage data before entering the sample into the sample room. This process is carried out for 20 minutes. After that, the simple-packaged cooking oil is entered and let stand for approximately 1-2 minutes so that the gas or aroma in each sample reaches the sensor, then the data is carried out for 20 minutes for every 30 seconds. The simple-packaged cooking oil is heated before testing for 5-8 minutes and reaches the temperature of about 120°C. Then the first sample is removed from the sample room and turns on the DC fan to remove the remaining aroma through the door for 5 minutes. Then wait for the sensor to stabilize for up to 20 minutes. This activity was repeated for samples of bulk cooking oil and used cooking oil. Data were collected for 5 days and every day there was one data for each sample.
3. Results and Discussion

Before the sample is tested, the e-nose system equipment is tested first such as LCD testing, adaptor output voltage, and arduino nano microcontroller. Then the e-nose system equipment is switched on for 20 minutes and records the sensor chamber output voltage before the sample is inserted. The result of the sensor's baseline voltage can be seen in figure 4. The baseline voltage of the sensor is 146 mV. This voltage value is the sensor output voltage from the air in the sensor room.

![Figure 4. The baseline voltage of e-nose system before sample is entered.](image)

Then data recording is done after the sample is entered into the sample room. The sample waited for 1 minute, so the gas or oil aroma entered to the sensor room. Data were collected every 30 seconds for 20 minutes. The oil samples tested were simple-packaged cooking oil, bulk cooking oil, and used cooking oil. The output voltage of each oil for the first day was shown by figure 5. Then data collection was carried out again until the fifth day. The output voltage data for these oil aromas can be seen in figure 6.
Figure 5. The output voltage of cooking oil aroma for the first day.

Figure 6. The output voltage of cooking oil aroma for (a) the second day, (b) the third day, (c) the fourth day, and (e) the fifth day.
Figure 5 and Figure 6 show that the aroma of cooking oil has a good response. This can be seen from the value of the e-nose system sensor output voltage increased compared to the baseline voltage. However, the value of the output voltage decreases over time up to the twentieth minute. In the twentieth minute, the value of the output voltage is almost the same as the baseline voltage [13-14]. Because no more cooking oil aroma can be smelled by the e-nose system sensor. The aroma of cooking oil can be smelled by the e-nose system sensor when the sample is heated and produces gas. In the twentieth minute, the cooking oil temperature has reached room temperature which results in reduced gas production.

The average output voltage of cooking oil in this study was 172.3 mV, 204.8 mV, and 181.4 mV for samples of the simple-packaged cooking oil, bulk cooking oil, and used cooking oil, respectively. The highest average output voltage is the bulk cooking oil while the lowest value is the simple-packaged cooking oil. Meanwhile, the used cooking oil is between the simple-packaged cooking oil and the bulk cooking oil. The used cooking oil that is used in this study is the simple-packaged cooking oil. It has been used several times. It shows that the aroma of the simple-packaged cooking oil increases when it is used. The bulk cooking oil in Indonesia's market is derived from palm oil and purified oil from used cooking oil. So, this tool succeeded in distinguishing the three types of cooking oil.

4. Conclusion
A tool to distinguish the aroma of cooking oil has been successfully made using the e-nose system. The highest output voltage is the bulk cooking oil with a voltage value of 204.8 mV. While the lowest output voltage is the simple-packaged cooking oil with a voltage value of 172.3 mV. The used cooking oil is the result of using simple-packaged cooking oil several times. It has an output voltage of 181.4 mV. This result shows that the aroma of cooking oil will increase when cooking oil is used several times. The more often cooking oil is used, the more smell is produced.

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