Design of Integrated Polarizer for Detection of Lard Impurities in Cooking Oil

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Abstract. This research was conducted to find the "fingerprint" of the existence of lard in vegetable cooking oil. Integrated Polarizer is composed of light source, polarizer, analyzer, cuvette, electrodes, and a camera. This tool works based on the transmission polarization method. Cooking oil used is palm oil that has been contaminated with chicken oil and lard. The light source used is a green laser with a wavelength of 532 ± 10 nm. Measurements are made by observing the change of transmission polarization angle. The results show that palm oil which contaminated by lard has the greatest polarization angle change compared to pure palm oil. The content of saturated fatty acids in lard is greater than pure palm oil resulting in a greater change in transmission polarization angles. From the results showed that integrated polarizer can be used for detection of lard impurities in cooking oil.

1. Introduction

Various types of cooking oil such as vegetable cooking oil (coconut, palm, soybean, corn, olive, etc.) or animal fried oil (chicken, goat, cow, pig, etc.) have been produced to meet the needs of the community. People not only use pure vegetable cooking oil alone in everyday use, but already mix vegetable frying oil with animal oil to produce a taste of cuisine more tasty.

Lard is one of the common ingredients commonly used by people, such as for the manufacture of cosmetics, soap, cake cheese, and even now mixing lard into vegetable frying oil has been done. It makes the majority Muslim population of Indonesia, who are very concerned about the halal level of a food product, should be more careful in buying cooking oil. Because if the cooking oil is contaminated or mixed with lard, it indicates that the oil becomes non-halal (illegal) [1]. Therefore, in addition to the methods needed to detect the quality of cooking oil, a method that can detect piglet pollution is also required. Until now in Indonesia, the tools for the detection of lard contamination in cooking oil have yet to be [2].

One of the most recent methods used to identify the presence of pork content in foods is the Liquid Chromatography-Mass Spectrometer (LCMS) method by combining two mass analyzers within the instrument moment (LC-MS/MS). This method has successfully detected the presence of pig content in gelatin [3]. However, the LC-MS/MS method is quite complicated to use and the tools used are expensive, therefore a simpler alternative method is needed.

One alternative method that can be done for quality testing and halal level of cooking oil is by light polarization method. Previous research has shown that changes in light polarization angles, either natural or induced by electro-induction, are capable of significantly differentiating the quality of various cooking oils [4]. So far polarization and electro-optics have never been used by other
researchers, and have not been used by SNI as a parameter of cooking oil quality test. With natural polarization, we can show the relative quality of different types of vegetable and animal oils quickly and accurately [5]. Whereas with electro-optics, early indications show probabilities as the only method and provide the only parameter for cooking oil [6].

Initial studies that have been done by Yuliandy, et al [4] and Firdausi & Rahmawati [5] show that the polarization angle is greater in animal oils than vegetable oils, especially pig oil with the greatest polarization change. However, lard contamination in other vegetable or animal oils has not been thoroughly tested. When compared, pure vegetable oils with vegetable oils that have been mixed with lard, the oil contaminated with pig oil will have a fairly high polarization value. The prospect of the polarization method for detection of lard contents in vegetable oil is still unanswered.

For that required design of integrated polarizer for detection of lard contamination mixed into vegetable cooking oil. The design prototype is expected to be able to be applied to improve the safety of food products in the case of development of fast and accurate detection of contamination on food products especially cooking oil, also to know halal level of foodstuff.

2. Experimental Methods
The equipment used in this research is (1) incandescent and green laser with wavelength 532 ± 10 nm, (2) Polarizer with scale 0º to 360º, (3) Cuvettes with FLP Disposable Fluorometer all transparent side with path length optics 3 cm, (4) High DC power source power supply with 0-6 kV voltage, (5) Two metal plates 3x5 in size and 2cm, (6) Multimeter type Sanwa Multimeter Digital CD-772, (7) HD Pro Camera C920 webcam connected to computer. The materials used in this study were 1 sample of palm oil and 7 samples of palm oil mixed with lard, with composition of lard is 0.5 mL, 1 mL, 1.5 mL, 2 mL, 3 mL, 4 mL, and 5 mL with a total volume of 5 mL. All equipment is designed as shown in figure 1.

After the tool design, the first step is to calibrate the tool using the malus law to ensure the feasibility and accuracy of the tool, by adjusting the angle of the polariser and the analyzer in order to obtain a minimum intensity value. In the second stage, the linearity test is done by using sugar solution, by observing the change of the transmission polarization angle. The next step is the implementation of the tool to observe the change of light polarization angle for the sample of cooking oil by natural polarization method with green laser. Then observed the polarization of electrooptic transmission by adding a voltage of 0-6 kV.

3. Results and Discussion
Design of Integrated Polarizer for Detection of Lard Impurities in Cooking Oil consists of (1) Green Laser as a light source, (2) Polarizer, (3) Cuvettes as a sample place, (4) Metal plate, (5) Analyzer, (6) HD Pro Camera, (7) High DC power source power supply, (8) Packet Computer. Each component is arranged as shown in Figure 1.

Figure 1. Design of Integrated Polarizer
After the tool component is arranged as Fig. 1, the next step is to calibrate the tool to ensure the feasibility and accuracy of the tool by adjusting the angle of the polarizer and the analyzer in order to obtain the minimum intensity value. The calibration principle is based on Malus’s Law (equation 1), that the intensity of the transmitted beam will be maximum when the two transmission axes are parallel (θ = 0° or 180°) and will be zero (perfectly absorbed by the analyzer) when the two transmission axes are perpendicular [7].

\[ I(\theta) = I_0 \cos^2 \theta \]  

(1)

with \( I(\theta) \) is the amount of light passed at angle \( \theta \), and \( I_0 \) is the amount of light polarized.

After calibration, the next step is linearity test by using sugar solution. Sugar solution is one solution that has active optical properties because the molecule has a chiral structure, so it can rotate the polarization plane. At this stage an observed change in the polarization angle of the sugar solution sample. The test was conducted by using polarization method of transmission with light source that is incandescent and green laser with wavelength 532 ± 10 nm. Test results showing the change of polarization angle to the difference of sugar concentration can be seen in Fig. 2 and Fig. 3.

**Figure 2.** Change of transmission polarization angle in sugar solution

**Figure 3.** Change of transmission polarization angle in commercial sugar solution

From Fig. 2 and Fig. 3, it can be seen that the increasing sugar concentration, the value of the change of polarization transmission angle (\( \beta \)) will be increase. The more sugar concentration increases, the density of the molecule will increase. Therefore, the change of polarization angle will be
directly proportional to the increase of sugar concentration to obtain a linear relationship. These results indicate that analyzer and polarizer can be used for research.

3.1 Integrated Polarizer for Detection of Lard Impurities in Cooking Oil

The sample used is pure palm oil and palm oil that has been mixed with lard with a total volume of 5mL in a cuvette. Table 1 shows the variations in the composition of the lard mixture.

Table 1. Variations of Lard in Palm Oil with a Total Volume 5 mL in a Cuvette

| Code | Lard Composition (mL) |
|------|-----------------------|
| B1   | 0.5                   |
| B2   | 1                     |
| B3   | 1.5                   |
| B4   | 2                     |
| B5   | 3                     |
| B6   | 4                     |
| B7   | 5                     |

Then observed the changes of natural transmission polarization angle (without providing a voltage) and the change of the polarization angle of the electro-optical transmission by providing a voltage on the metal plate of 0 kV-6 kV.

Figure 4 shows the comparison change of transmission polarization angle between pure palm oil and palm oil mixed with lard with variation composition. Figure 4 shows that the change in the transmission polarization angle tends to increase against the amount of lard composition in palm oil. The change of transmission polarization angle in the palm oil that has been contaminated with lard is greater than pure palm oil. The content of saturated fatty acids in lard has an effect on the increase of polarization angle change. The saturated fatty acid of lard that binds to the palm oil molecules forming short chains and triggers the movement of the Van Der Waals between molecules to become smaller. This effect is predicted to be a physical process responsible for the change of polarization angle. The weaker the interaction force between molecules, the greater the change in the angle of polarization.

Figure 4 Changes in the polarization angle of transmission of palm oil that has been contaminated with lard without providing a voltage
Next observation is made to change the angle of transmission polarization by giving voltage 0 kV – 6 kV. Figure 5 shows changes in the polarization angle of transmission of palm oil that has been contaminated with lard with providing a voltage 0 kV – 6 kV. The results show a graph of changes in polarization angles that change quadratically to the magnitude of the electric field. This quadratic increase is due to the initial existence of free radicals and the formation of free radicals when subjected external electric field [8].

**Figure 5.** Changes in the polarization angle of transmission of palm oil that has been contaminated with lard with providing a voltage 0 kV – 6 kV

The addition of voltage to the polarization will create an electric field that will affect the oil molecules. This electric field will interact with the electric field from the light source so as to generate a resultant electric field which causes a larger polarization angle change compared to the natural polarization.

**4. Conclusion**

From the results of the research, design of integrated polarizer can be used well for detection of lard impurities in cooking oil. Integrated polarizer that work based on the polarization method has successfully distinguished the cooking oil (palm oil) that has been contaminated or mixed with lard. The change in transmission polarization angle on palm oil that has been contaminated with lard will be greater than that of pure palm oil. The method is simpler and easier to study the interaction of light with matter for special condition. Results of the design tools are expected to replace equipment existing standard spectrometers are mostly foreign-made that the price is very expensive.

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**References**

[1] Indonesia. Undang-undang tentang Jaminan Produk Halal. UU No.33 Tahun 2014. LN No.295 Tahun 2014. TLN No.5604

[2] Badan Standardisasi Nasional ICS 67.200.10, 2013. Syarat Mutu Minyak Goreng, sni 3741: 2013. Jakarta.

[3] Tan, CT., & Lock, W., 2014. Are Pork Extracts Present In My Gummy Bears? Gelatin
Speciation by LC-MS/MS. Food and Environmental AB SCIEX.

[4] Yulianti, Eva., Indriyani, Y., Husna, A., Putri, N.K., Murni, S., Amitasari, R., Putranto, A.B., Sugito, H., dan Firdausi, K.S., 2014. Deteksi Dini Kualitas Minyak Goreng dan Tingkat Kehalalannya Menggunakan Polarisasi Alami. Berkala Fisika, 17(3), pp.79–84.

[5] Firdausi, K.S., dan Rahmawati, H., 2015. Review of a Simple Powerful Polarizer for Testing of Several of Edible Oil Quality. Berkala Fisika, 18(4).

[6] Firdausi, K.S., Sugito, H., Amitasari R., dan Murni, S., 2013. Metode Elektrooptis sebagai Pendeteksi Radikal Bebas dan Prospek untuk Evaluasi Total Mutu Minyak Goreng. Indonesian Journal of Applied Physics, 3(1), pp.72–78.

[7] Firdausi, K.S., Sugito, H., Amitasari R., dan Murni, S., 2013. Metode Elektrooptis sebagai Pendeteksi Radikal Bebas dan Prospek untuk Evaluasi Total Mutu Minyak Goreng. Indonesian Journal of Applied Physics, 3(1), pp.72–78

[8] Firdausi, K.S., Susan, A.I., dan Triyana, K., 2012. An Improvement Of New Test Method For Determination Of Vegetable Oil Quality Based On Electrooptics Parameter. Berkala Fisika, 15(3), pp 77-86.