



## Design of Integrated Polarizer to Evaluate Quality of Cooking Oil Based on the Fluorescence Polarization Method

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### ABSTRACT

An integrated polarizer was designed as an alternative test tool to evaluate quality of cooking oils. Integrated Polarizer was composed of light source with wavelength of  $532 \pm 10$  nm, polarizer, analyser, cuvette, electrodes, and high voltage source. In this research, the tool works based on the fluorescence polarization method. Measurements were made by observing the fluorescence polarization angle changes that occur and by applying an external electric field at the samples using high voltage of 0-9 kV in the parallel plate. The results show that the expired cooking oil has a greater polarization angle than the edible cooking oil. The results also show that the change in the polarization angle will increase in proportion to the increase of the heating time. The condition of saturated fatty acids in each sample has an effect on the change of polarization angle.

### 1. Introduction

The importance of cooking oil for human consumption makes cooking oil to be aware of its quality. According to the National Standardization Agency [1], the measurement of cooking oil quality is based on parameters such as smell, taste, color, moisture content, acid number, linoleic acid, and metal contamination (Pb, Hg, Cu, As) which are respectively each parameter is tested with different equipment.

Oil quality testing using only one parameter in the form of polar components can be done by methods such as chromatography, dielectric sensors, NMR, and NIR [2]. Whereas Sangdehi [3] and Yavari et al [4] examined the formation of polar molecules, the emergence of free fatty acids during use, and changes in viscosity after consumable oils, using VIS-NIRS spectroscopy. Gerde et al [5] have also investigated oil degradation based on the formation of polar components, free fatty acids, and dienoic acid using NIR Spectroscopy, as the fastest device.

Calorimetric (DSC) Differential Scanning Utilization has been used to investigate degradation of oil quality due to thermal oxidation [6] and to detect the formation of polar components, changes in thermal properties, and changes in other chemical compositions [7]. Chemosensory equipment used in the food industry as a controller and monitoring tool, and FTIR-ATR is also used to determine the quality of cooking oil based on expiration (rancid) using parameters of dielectric constants, peroxide numbers, and the formation of free fatty acids [8].

Another relatively new indicator used to test the quality of cooking oil is the rate of change in trans fatty acids during heating of cooking oil, but also must first experience a variety of treatment and long testing variations [9]. Kress-Rogers et al [10] have

developed oil quality measuring sensors based on their viscosity. Although there is a correlation between oil quality and viscosity, the method is still less sensitive to distinguish the type of oil tested. Preliminary studies that have been carried out by Sutiah et al [11] using physical parameters of viscosity and refractive index are the initial steps, in order to investigate physical parameters that can be measured with simple equipment using relatively easy to reach costs, but not yet accurate results of differences between standard oils still fresh with consumable oil. Abe et al [12] used oil refractive index as a parameter of oil quality control in real time using a fiber optic refractometer. The method is quite beneficial because it only requires a small amount of volume, and the sample is not contaminated. Only, for refractive index above 1.47, a less sensitive measurement is produced.

Even though these references claimed to have many successes, several tests that used many stages and samples had to be treated early (eg experiencing pamanasan), indicating that the testing methods required a lot of time, cost, and handling. These things in addition to adding a variety of testing methods, but also add to the complexity of testing the quality of cooking oil if all components must be carried out. In abroad, so far there are several practical tools that are claimed to be used by the community to determine oil quality based on expiration [13]. Unfortunately, in these instruments, the use of test parameters is only based on a single indicator. Some tools only work on the basis of color changes (the appearance of free fatty acids), while other tools are only based on the dielectric properties of oil (the appearance of polar molecules).

The number of parameters that must be tested along with methods that are very varied, add to the

complexity of testing cooking oil. In addition, most existing equipment is relatively expensive. For this reason, it is necessary to build a simple but reliable equipment system that can be used to test the quality of cooking oil which is easier, shorter, more accurate, with relatively cheaper prices. So far, it has never been realized that polarization of light can be used to distinguish the quality of various types of cooking oil. Although the change in the resulting polarization angle is relatively small, the value of the change can still be measured manually with a pair of polarizer[14]. This method is also simpler than practical. which is more reliable than the SNI standard test [15].

In the design of this tool a fluorescence method is used, which is indicated by changes in the angle of light polarization when the sample is given an external electric field. As far as the results of the literature study to date, cooking oil testing uses electrooptical properties including new things.

## 2. Experimental procedure

The equipment used in this research consisted of main equipment and supporting equipment. The main equipment was composed of 1) light source using a green laser with a wavelength of  $532 \pm 10$  nm, 2) polarizer that functions to select the direction of the electric field from the light source passed on the sample with a scale of 00 to 3600, 3) analyzer that serves to measure the change in angle polarization of light after passing the sample on a scale of 00 to 3600, 4) A cuvette that functions as a container for the sample to be tested. The overall cuvette used has a transparent side with an optical path length of 3 cm, 5) The source of a high DC power supply that functions as a static electric field generator with a voltage of 0-9 kV, 6) The camera functions to observe changes in polarization angle after passing through the analyzer, 7) Two metal plates parallel with size is 3x5 and 2 cm apart which function to induce samples, 8) PC which connected to camera to observe changes in polarization angle. All equipment was designed as shown in figure 1.

While the supporting equipment used in this research consisted of a multimeter type Sanwa Digital Multimeter CD-772 which serves to see the voltage from the power supply source, furnace is a device used to heat the sample, a glass beaker with a 50 ml volume serves as a sample container when heated.

The samples used in this research were expired cooking oil (A) and new cooking oil (B). The samples A and B were used as test material to test equipment whether the samples can be distinguished or not. The treatment was given to the sample by heating each sample with a time variation of 30 minutes, 120 minutes and 240 minutes. Sample testing is done by observing changes in polarization angle by giving a voltage of 0-9 kV on parallel metal plates.

## 3. Results and discussion

Designed of integrated polarizer to evaluate quality of cooking oil based on the fluorescence polarization method are shown in figure 1.

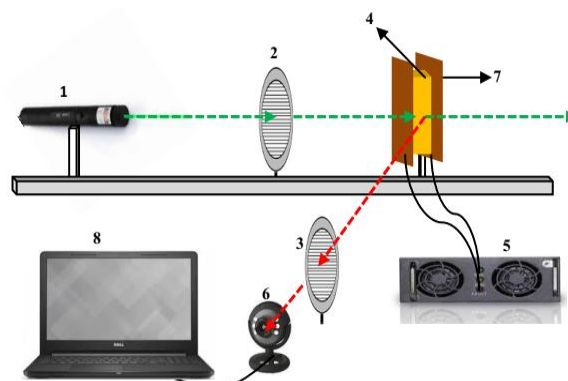


Figure 1 Integrated polarizer

The interaction between photons and fluorescence molecules is polarization by fluorescence (Fig.2). The polarized light source is induced by the fluorescence beam and at any angle it will not emit the same intensity of light. The light source propagating on the X axis and polarized on the Z axis will affect the sample. Photon energy will excite electrons in the sample so that fluorescence occurs. The fluorescence will then be polarized in the Y-axis, then the value will be changes in the polarization angle [16].

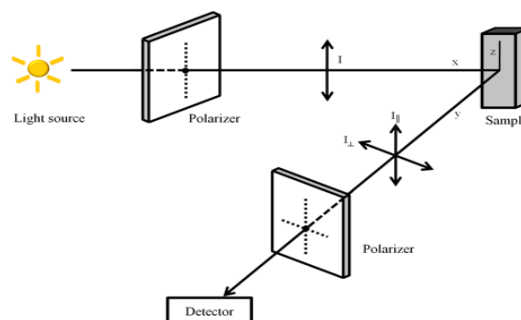


Figure 2 Fluorescence polarization

Fluorescence is the emission of electromagnetic waves by a substance after the absorption of other electromagnetic waves. The fluorescent beam emitted will have a wavelength that is greater than the wavelength of the initial electromagnetic wave. In this research, used a green laser as light source with a wavelength ( $532 \pm 10$ ) nm. The green laser that is passed through the polarisator will affect the sample (cooking oil) so that florescence occurs.

Figure 3 is the result of the design test tool that used to observe the comparison between the expired cooking oil and the new cooking oil based on the method of fluorescence polarization. The results show that the expired cooking oil has a greater change in polarization angle than the new cooking oil. The difference in polarization angle can be caused by the magnitude of the fluorescence intensity and the active optical properties of the oil triglyceride molecules. As a comparison to show that the design of the tool can be used to distinguish the quality of the sample of A (expired) cooking oil and a new cooking oil (B) that is by giving the heating treatment to each sample for 30 minutes, 120 minutes and 240 minutes. The results show that changes in the polarization angle will increase if the

sample is heated longer. The results also show that samples that have expired have a greater change in polarization angle than new cooking oil. Figure 4 shows a comparison of changes in polarization angle of sample A and sample B with heating treatment.

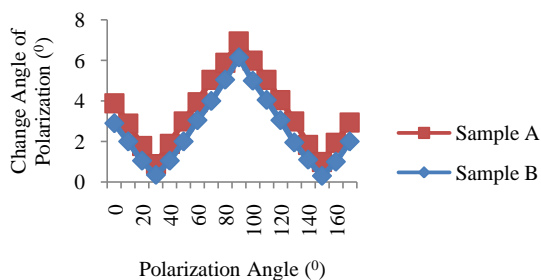


Figure 3 Changes in fluorescence polarization angle on cooking oil without heating

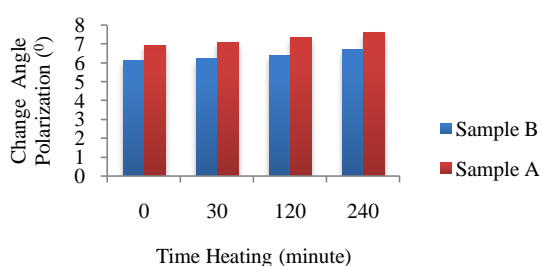


Figure 4 Changes in fluorescence polarization angle on cooking oil with heating treatment

Expired cooking oil contains more saturated fatty acids than new cooking oils. Heated cooking oil has poor quality due to saturated fatty acid content. The difference in fatty acid content of each sample affects the change in polarization angle. The results of Gas Chromatography-Mass Spectrometry (GC-MS) tests conducted by Firdausi et al. [17] show that changes in polarization angle indicate a relationship between polarization and fatty acids as the main component of triglyceride molecules in cooking oil.

The next quality test for cooking oil is by giving an electric field to the sample with a voltage variation of 0-9 kV. Electric field is given by flowing electric current on 2 metal plates placed parallel to the sample. The test results as shown in Figures 5 show that the electric field given to the sample influences changes in the polarization angle. The higher the electric field is given, the greater the change in polarization angle.

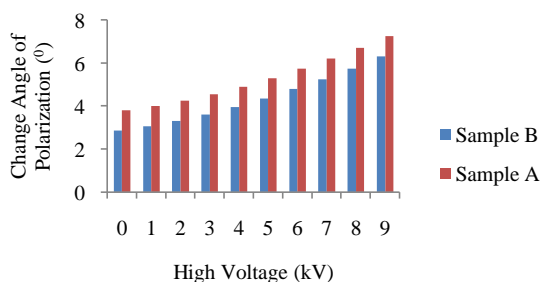


Figure 5 Changes in fluorescence polarization angle on cooking oil by giving electric field to the sample

The results of the study indicate that the fluorescence polarization method can be used to differentiate expired cooking oil and new cooking oil. By providing a heating treatment and a high voltage electric field to the sample, changes angle of polarization can be clearly observed. In the future, integrated polarisator design and fluorescence polarization methods can be used to test halal ingredients and food products in liquid form.

#### 4. Conclusions

The design of integrated polarizer tools can be used to evaluate the quality of cooking oil based on the fluorescence polarization method. Changes in the fluorescence polarization angle in the expired cooking oil is greater than the new cooking oil. The length of heating time and the provision of an electric field in the sample also affects the increase of the change in polarization angle. In the future, the method of fluorescence polarization will be a reliable method for evaluating the quality of cooking oil and can be used to test halal ingredients and food products in liquid form.

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