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# REVIEW OF A SIMPLE POWERFUL POLARIZER FOR TESTING OF EDIBLE OIL QUALITY

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***Abstract***

*In this paper, we have shown that a simple pair of polarizer can be used to measure natural optical activity in total complex oil (vegetable oil and fats). A similar concept with quantum physics has been discussed to describe briefly the probability in finding a particle within certain region with the change of polarization due to the interaction light with saturated fatty acids. The light source was fluorescence lamp and the experimental condition was kept stable, i.e. constant temperature and constant humidity. The angle of polarization was measured repeatedly until 50 times. Our relative uncertainty measurement has been obtained up to 5% and this is obviously clear to be able to differentiate various different quality of oil. More important result is that ordinary light polarization can be used as powerful test to show various quality level of oils better than recent standard methods. A good prospect has also been obtained for halal level testing. It is found that average value of polarization in lard (pig oil) is relatively higher than the others.*

***Keywords:*** *polarization, oil quality, saturated fatty acid*

***Abstrak***

*Penelitian ini membuktikan bahwa sepasang polarisator sederhana mampu digunakan untuk mengukur aktivitas optis alami dari minyak goreng (minyak nabati dan hewani. Konsep serupa dengan fisika kuantum juga telah dibahas secara singkat untuk menggambarkan kebolehjadian menemukan partikel dalam daerah tertentu dengan perubahan polarisasi akibat interaksi cahaya dengan asam lemak bebas. Sumber cahaya yang digunakan dalam penelitian adalah lampu TL dan kondisi eksperimen dipertahankan konstan, misalnya suhu sampel dan kelembaban ruang. Sudut polarisasi diukur berulang-ulang sampai 50 kali. Kesalahan relatif pengukuran diperoleh sampai 50% dan ternyata hal ini sangat jelas mampu membedakan kualitas relatif dari berbagai minyak goreng. Hasil lain yang lebih penting adalah polarisasi cahaya alami dapat dipandang sebagai metode yang handal melebihi metode standar untuk menunjukkan secara dini tingkat-tingkat kualitas minyak goreng. Prospek lain yang cukup menjanjikan adalah penggunaan metode polarisasi untuk uji tingkat kehalalan minyak akibat cemara lemak babi, karena ternyata lemak babi menunjukkan polarisasi tertinggi relatif terhadap minyak-minyak yang lain.*

***Kata Kunci****: Polarisasi, kualitas minyak, asam lemak jenuh*

## Introduction

In our previous study, the standard parameters of vegetable oil quality and the methods have been considered to be complicated and, of course, it is very difficult to be obtained simultaneously [1-4]. A promising method that leads to a single parameter of oil quality is so called electro-optics method. Through this method, the small optical activity of vegetable oil can be increased significantly. We have proposed that it is a novelty finding of a single quality parameter of edible oil, which could replace all recent standard parameters. This single parameter has been presented as average maximum dissociation energy due to Van Der Waals interaction, which is still very interesting to be researched. And it is an important task to obtain this relation with the change of

polarization. [2 - 4]. It was found that optical activity of edible oil is very small and its change of light polarization is difficult to be measured using ordinary polarimeter [2, 3]. The recent studies told that an ordinary polarimeter has been hardly used to measure this small optical activity [5]. With average value of light polarization below 1°, a question to be addressed in this paper is how a simple pair of polarizer with smallest scale 1° could measure small optical activity in edible oil. Here we demonstrate that with the simple polarizers, it could be done. More important result is that the ordinary light polarization has shown as powerful tool to show various quality level of oils more practical than recent standard methods. A good prospect has also been obtained for halal level testing. It is found that average value of polarization in lard (pig oil) relatively higher than the others.

A simple polarizer usually has smallest scale of 1°. In case for only single measurement, a light polarization below 1° should be read as 0° (usually in edible oil) with the uncertainty 0.5°. In expired oil or fats the change of polarization can be more than 1°. By using simple polarizers, it should be read as an integer value 1°, 2°, etc., with the same uncertainty. Two different edible oils would give the same value of 0° of polarization, which is obviously undistinguishable. A solution for this instrument could be achieved, for an example, by dividing the scale in to smaller angle than 1°, i.e., one should obtain the smallest scale of 0.5°, 0.4°, or 0.2°. However, it still will give a significant uncertainty for a single measurement, because the change of angle polarization in edible oil is below 1°, which gives high relative errors. Another solution may be obtained by using high precision of light intensity measurement, however, this would lead to a complicated instruments and its combination with electronic devices, which in our opinion is not inline related with our idea above. A better solution can be obtained normally by using repeated measurement, instead of using single measurement. Our experience shows that the most probable inaccuracy of change of polarization during this measurement comes from parallax error of direct observation of light intensity via Malus' law. And it can be reduced by several repetition of data acquisition. Several times of repeated measurement of a polarization angle should give more accuracy of result of observation than a single measurement. To obtain an accurate result of the observation for a single value of change of polarization in edible oil, we have used standard error for the uncertainty of experimental result within two weeks of measurements.

**Methods**

In this experiment, we referred to the reference [2]. We prepared various standard and not-standard oils without any preliminary treatments. All samples have been kept well and assumed to be unchanged within a year. The standard oils have been assumed fulfilled by Indonesian National Standardization (SNI), and have various different expiry time. The experimental condition was maintained to be constant during measurement in day by day. The most important physical parameter was sample temperature, which was always maintained in to room temperature and should not exceed more than 2°C. The sample temperature and humidity during measurement were altered between circa 26°C and 27°C, and between 60% and 70%, respectively, and considered to be constant. To obtain highest accuracy from measurement, an angle of polarization change was measured repeatedly until 50 times.

**Result and Discussions**

Fig. 1 shows the change of polarization from different quality levels in

two different palm oil from the same brand, measured within two weeks. It is very obviously observed, that both palm oil are distinguishable from the result in each day during the measurement. Even some data shows high discrepancy such as in day 5, day 9, and day 11. We can conclude that still there is almost unchanged quality level of oil within 2 weeks of measurement.

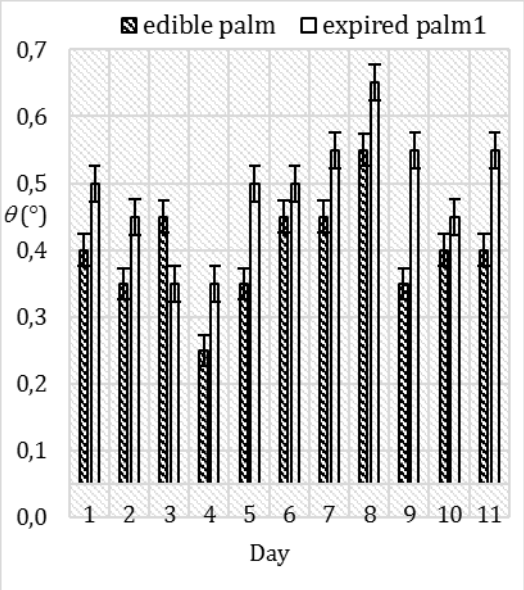


Fig. 1 the difference of change of polarization between two different levels of palm oil quality

It is very clear as well, that in Fig. 1, the edible oil shows better quality than the expired one indicated by smaller change of polarization. A slightly, anomaly difference comes out in day 3 which it could be from beginning condition of samples before data acquisition due to intermolecular Van Der Waals interaction of triglycerides of samples. Other reasons of this disturbance are still plausible to be investigated thoroughly. However, these will be taken into account as an experimental error for the whole average value within all days of experiment. This anomaly behaviour of polarization resulted in day 3 from fig. 1 is usually ignorable due to rejected data. Using weighted error for all days of measurement, we have obtained that the change of polarization value for both of edible and expired oil is 0.35°±0.03° and 0.46°±0.03°, respectively, and again it is obviously differentiated. The discrepancy between edible palm and expired palm1 above is obtained to be 0.11°±0.01°.

Although several times of repeated measurement seems cumbersome, it still provides better information for preliminary oil quality than recent standard methods. As these have been evaluated by Sugito and Firdausi [2] and Firdausi et al [3], standard parameters such as number of free fatty acids or peroxide value could not be used optimally and preliminary to detect the difference between edible and expired oil, especially in natural condition.

For the same interval time, several samples have been also carried out and we present them in the following discussions. Fig. 2 shows various average values of polarization angle from 6 different levels of oil quality, after 2 weeks of measurement, with their uncertainty circa 0.03° calculated by using weighted error.

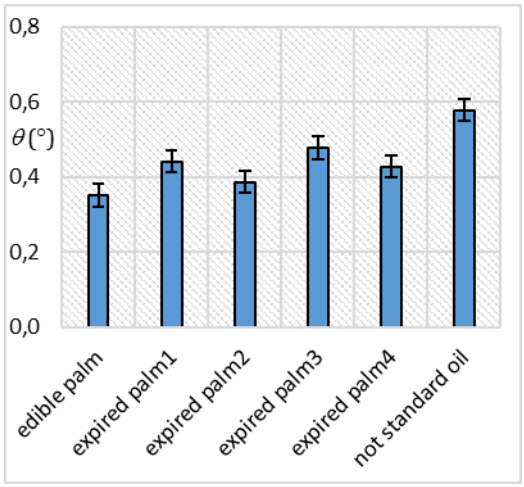


Fig. 2, the difference of change of polarization between 6 different levels of palm oil quality after 2 weeks of measurement (April – May 2015)

In fig.2, some expired oils show not so differentiated from edible oil, and perhaps they have been well kept in an appropriated condition. The not-standard oil shows highest change of polarization angle and again it is in agreement to the previous study [2 - 4]. The discussion of the origin of the increasing polarization angle is very interesting and still being developed, and for now the most reasonable physically explanation is the formation of saturated fatty acids or SFA in asymmetric triglycerides that influenced to the change of polarization. High polarization angle is very probably influenced by production of long chain of SFA [5]. An "under estimation" that a simple polarimeter could not be used to detect optical activity in total complex oil can now be neglected. The probability of change of polarization below 1° is clearly observable using several times repetition of measurement for single sample. It looks like a most probability distribution of particles that can be observed and found in a certain region, which is dependent on high value of $|\psi|^2$, where $\psi$ is related to particle wavelength according to quantum mechanics theory. The changed rotation of electric field of light from $E$ to $E\cos\theta$ due to "a small region" so called asymmetric triglyceride molecules could be analogically similar in this case, where $\theta$ is the change of polarization angle measured in this experiment. The value of $\theta$ is proposed to be proportional to the number of SFA formed in oil and simply written as $\theta \sim n$, where $n$ is the number of most probable long chain of SFA. The $c$ constant proportionality in equation $\theta = c\ n$, should reflect how effectively rotated the electric field of light in oil is. The long chain of SFA formed in asymmetric triglycerides also usually can be found in fats (animal oils) in high abundance. And for this real condition, our equation will give high polarization, as well. Fig. 3 describes difference of polarization between vegetable oils and fats (chicken oil and lard in this case).

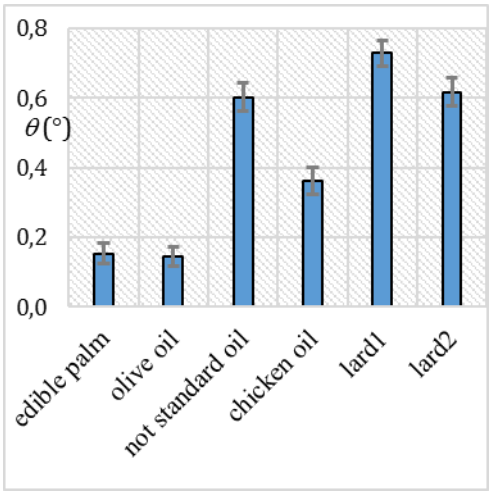


Fig. 3 different values of various oils conducted in three different days in 26, 27, and 28 August 2015

The measurement was conducted in 26, 27, and 28 August 2015. The lard1 and lard2 were bought in 4 June 2015 and 1 August 2015 respectively. The chicken oil was obtained in 24 May 2015. The expiration date of not-standard oil is not available and it is already long expired. And the expiration date of palm and olive oil are in 4 June 2017 and 29 October 2016, respectively.

In fig. 3, the discrepancy of polarization values between vegetable oils and fats are very obviously obtained just using a simple pair polarizer. The uncertainty of measurement in three days of measurement lies between 0.04° and 0.07°. It has been already discussed that SFA plays an important role in increasing optical activity of fats or expired oils more than vegetable edible oils [3]. And refer to similarity of the probability in finding a particle within a certain region, here we propose that $\theta$ (instead of wave function $\psi$) should provide high probability if it interacts with "a certain region" so called SFA. Namely high probability in finding a particle will be

obtained for large region, therefore the change of polarization $\theta$ would be also found if it interacts with high number of long chain of SFA, *n*. The proportionality between $\theta$ and *n* should be comprehensively investigated and proven by using, for an example, gas chromatography and mass spectrometer (GCMS). In fig. 3, highest polarization for lard will provide opportunity to develop this method for halal level investigation, however, proper characteristics of lard in polarization such as wavelength, intensity, temperature and so on, should be firstly found in order to obtain a certain 'finger print' of lard using simple polarization.

## Conclusion

The simple polarimeter in the experiment is capable to measure natural optical activity in total oil with uncertainty of measurement up to 0.03° using repeated measurement and weighted error. The result shows that this method can differentiate various level quality of edible oil and has prospect to test halal level of oil due to lard.

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