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Cooking Oil Quality Test Based on Changes in Polarization and Fatty Acid Composition

Heri Sugito[1], Ketut Sofjan Firdausi[2]

[1,2]Department of Physics, Faculty of Sciences and Mathematics, Diponegoro University Jl. Prof. Soedarto SH., Semarang 50275 Indonesia

Corresponding Author: Heri Sugito

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ABSTRACT

In this study, parameters on polarization in total natural vegetable oils and fats have been investigated by determining the relation between the polarization change and fatty acids (FA) composition. The change of light polarization was simply measured by using a pair of polarizer-analyzer to indicate the oil quality level. Various vegetable oils and fats were examined without any preliminary treatments. The experimental condition of the samples during measurement was assumed to be constant. It has been shown that various oils and fats have different angles of change of polarization, which indicates various oil quality levels relative to each other, in agreement with the previous works. Especially for vegetable oils, high change of polarization has been considered as low quality of oil.

Keywords: polarization, saturated fatty acid (SFA), unsaturated fatty acids (UFA)

INTRODUCTION

The light polarization in vegetable oils exists due to asymmetric triglyceride (TG) molecules. The reason for asymmetric TG molecules, which causes optically active, has been believed as the difference between the first and the third fatty acids (FA) in a TG molecule. Not only differing in composition, but also differing greatly in the chain length of fatty acids in TG has been considered to cause the optical activity of TG. The most important result has shown that a saturated TG was observed to be optically active if the chain length of the third FA was greater than first FA [1]. Meanwhile, our previous work has shown that TG in a complex mixture of vegetable oils shows very small optical rotation using ordinary light. Average change where the R1 and R3 represent fatty acids of different lengths and quantities. Of polarization in standard edible oils has a value of rotation less than that without any preliminary treatments [2-5]. Although it is very low optically active, various types of oil show different small polarizations depending on the oil condition. It certifies that polarization could be used for a powerful preliminary test of oil quality [2]. Our work has also shown that the small value of rotation in oil can be increased significantly by adding an external electric field to the sample, or so-called electro-optics [3-5]. This leads to a new single parameter of oil quality, which is simpler than recent standard parameters according to the Indonesian National Standardization [6-7]. In electro-optics consideration, we have obtained important results that the electro-optics gradient of the polarization change from various degradation of oil quality is influenced by the predominant FA and is a linear combination of the main FA composition in the palm oil [8]. Another interesting application of electro- optics technique has been used to indicate waste cooking oil treatment using ZnO thin film for Photo-catalytic [9]. In this paper, the change of polarization due to asymmetric TG is supposedly a linear combination of the number of SFA and UFA of TG molecules according to the reference [8].

METHODS

Various vegetable oils were used as samples in the experiment. The sample was obtained from the market, assumed to be fulfilled by SNI. The fats were chicken oil and lard oil obtained from the traditional market and as well as expected from a standard extraction. The change of polarization was determined by using a pair of polarizer-analyzer and measured in degrees. The experiment was carried out from May to August 2015. All samples were measured under the same conditions at room temperature without any previous treatment. Any change of sample temperature not more than 1 °C was considered to be not significant in contributing to light polarization. The samples were examined by using GC-MS for the determination and identification of the SFA and UFA fractions.

RESULT AND DISCUSSION

Figure 1 shows the polarization change in vegetable oils and animal oils, or fats. The palm1 (expired in 2014) is expired oil, and palm2 (expired in 2017) is edible oil. The fats, i.e., chicken oil and lard (pig oil), were used to evaluate the halal level for future information. The "halal level" means in this case that a possibility that an edible oil is contaminated by lard.

It is shown that expired oil (palm 1) has a higher change of polarization than the edible one (palm 2). In agreement with our previous work [2], in many cases, an expired oil always has a higher polarization than the edible or fresh one. It should be mentioned that recent standard methods could not be obtained simply and simultaneously due to various parameters. In our case, the difference between expired and edible oil is easily obtained by using polarization. Therefore, our method is much more powerful for the preliminary test of oil quality than the standard methods.

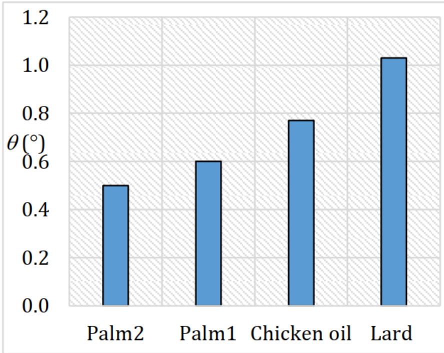

Fig. 1 the change of polarization in vegetable oils and animal oils. The animal oils or fats were represented by chicken oil and lard (pig oil), which were obtained in the market in May and June 2015. Palm2 is still edible oil (expired: 2017) and palm1 is already expired (expired: 2014)

As shown in Figure 1, the lard has the highest polarization compared to the others. This has provided a good prospect for the evaluation of halal level due to lard for the future. However, it remains a question why it has the highest polarization angle. It was still suspected that SFA and UFA play an important role in the change of polarization. For these reasons, it was then examined using GC-MS to obtain further information on the SFA and UFA numbers.

Table 1 shows the total fraction of SFA and UFA of the total samples obtained using a GC-MS instrument, and these are chosen only for the highest possibility that causes optical rotation in a high number of carbon atoms. The SFA labelled with C17:0 and C19:0 represents methyl palmitate ($C_{17}H_{34}O_2$) and methyl stearate ($C_{19}H_{38}O_2$), respectively. The double bond UFA assigned with C19:2 and the single bond assigned with C19:1 represent, respectively, methyl linoleate ($C_{19}H_{34}O_2$) and methyl oleate ($C_{19}H_{36}O_2$).

TABLE 1 List of oils, their expiration date, and the highest fraction of SFA and UFA.

Sample	expiration date	Fraction of Fatty acids				Change of polarization
		C17:0	C19:2	C19:1	C19:0	(°)
Palm 2	16/02/2017	0.3523	0.1061	0.4112	0.0336	0.50
Palm 1	25/10/2014	0.3602	0.099	0.4273	0.0329	0.60
Chicken oil	NA*	0.1927	0.1798	0.3979	0.0458	0.77
Lard (pig oil)	NA*	0.2009	0.1389	0.3456	0.0815	1.03

*** Both chicken oil and lard were bought on 24 May 2015 and 4 June 2015, respectively. The expiration date was not available.**

The increasing change of polarization in Table 3 was also accompanied by an increasing fraction of C19:0, except for palm oil, which showed almost equal change of polarization. It is possible that both C17:0 and C19:0 was very predominant in the optical activity of the whole oils or fats. If the long chain of R1 must differ from R3, these positions should be replaced by a short chain of FA and a long chain of FA, such as C17:0 and C19:0, respectively. The longer the chain of R3, the higher the optical activity of the TG. In this case, with a high fraction distributed among C17:0, C19:2, C19:1, and C19:0, the highest possibility that the optical rotation could be observed in asymmetric TG, the combination R1 = short chain of FA and R3 = C19:0 would be the best pair of fatty acids in TG in accordance with contributing the highest change of polarization.

From Table 2, the SFA of C19 seems to play the most important role in increasing the change of polarization. Our results seem in agreement with the previous results [8], in which the change of polarization is a linear combination of most FA, such as C20:2, C20:1, and C20:0 with fair correlation for C20:0 and strong correlation for C20:1. The dominated FA such as C20:1, and C20:0 in contributing to the polarization change is the understandable due to the long chain and most abundant molecule.

TABLE 2 Values of the linear coefficient of fraction of SFA and UFA

Fatty acids	Coefficient	Value (°)
C17:0	*a*	-4.5
C19:2	*b*	-6.5
C19:1	*c*	5.9
C19:0	*d*	9.6

CONCLUSION

The polarization has shown the oil quality level. In case of showing the difference between edible and expired oil, this method shows a powerful comparison to other standard methods. The change of polarization, so far, is related to the formation of SFA and UFA. The change of polarization is a linear combination of the number of the main FAs. The most dominant polarization in lard from chicken oil should take into account additional SFA, which has the highest coefficient of C19:0 from all samples and provides a good prospect for evaluation of the halal level of oil.

Declaration by Authors

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Conflict of Interest: No conflicts of interest declared.

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