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A Simple Polarization for Powerful Preliminary Test of Oil Quality Level

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Abstract. In this paper, light polarization has been used to indicate level quality of various vegetable oils. A new indication of level quality used here was change of light polarization, and was measured using a simple pair of polarizer-analyzer. The result showed that the degradation of oil quality until to its date of expiration was indicated by higher change of polarization. It was proposed that the saturated fatty acid methyl stearate ($C_{17}H_{34}O_2$) and unsaturated fatty acids methyl oleate ($C_{19}H_{36}O_2$) in triglycerides molecules were the most fatty acids that could be responsible to the degradation of oil quality. This method apparently has been relative more powerful than standard parameters such as free fatty acid (FFA) test.

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

Introduction

Change of polarization takes place in natural triglycerides (TG) due to its asymmetric molecules. When a light passes through TG in total mixture natural oils, it changes very small rotation of polarization in comparison to glucose solution [1]. In total vegetable oils, according to our works, the rotation angle of polarization has been measured in average less than 1° at room temperature depending on the oil condition [2,3]. Due to its small change of polarization, we have assumed that the scientists might not be interested in polarization as tool for investigation of oil quality level.

So far according to Indonesia National Standardization (SNI) the polarization is not included as standard parameter of oil quality [4,5]. At a view point of our study, the various parameters of oil quality with its various standard methods are extremely difficult to be conducted and obtained simultaneously [2-3,6]. For some reasons for rapid validation, some people reduce these many standard parameters become 2 or 3 standard parameters only. A standard test, such as free fatty acid (FFA) test or peroxide value (PV) test, is usually adequately to assess the experimental results.

According to our previous works, high polarization in vegetable oils indicates low level of its quality. The increase of polarization is due to increase of formation of FFA, PV, saturated fatty acid (SFA) and some other molecules [6]. But which is most responsible for the degradation of oil quality until its time limit of expiration? It is for us is not yet clear. This paper studies polarization of light to determine of oil quality level, and to investigate the most responsible molecules that most probable cause to expiration matter.

Material and Method

Various vegetable oils from different brands were obtained from the market, assumed to be fulfilled by SNI, and rearranged according to their different expiration date. Table 1 showed the list of standard vegetable oils with its different expiration date.

The experimental procedure referred to Firdausi et al. [7], but in this case was conducted without any external electric field. The source of light was TL lamp-23W and a 60W-ligth bulb. The experiment was done from May-September 2014 and from May-August 2015. All samples were measured in the same condition at room temperature without any previous treatment. The change of polarization was determined by using a pair of polarizer-analyser and measured in°.

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Table 1, List of standard vegetable oils and its expiration date. The minus sign "–"in the 3rd column indicates that the oil was still fresh during research before time of expiration. The measurement conducted from May until September 2014.

Standard vegetable oil	Expiration date	time of expiration [months]
VCO	15/05/2017	-36
Palm2	23/06/2016	-23
Olive	02/03/2016	-20
Palm1	12/11/2015	-16
Soybean2	15/12/2015	-15
Coconut	26/08/2015	-13
Rice	09/07/2015	-12
Corn	19/05/2015	-10
Coconut	17/03/2015	-8
Palm2	25/10/2014	-4
Soybean2	30/08/2014	0
Soybean1	31/05/2014	0
Palm1	27/12/2013	5
Corn	09/11/2012	16
Rice	08/12/2012	17
Soybean2	30/09/2012	19
Soybean1	28/06/2011	32
VCO	30/06/2008	72

The measurement of SFA was used from animal oil i.e. chicken oil, with the assumption that animal oil consisted of high SFA concentration only and hence the part of animal oil was proportional to part of SFA. We have considered that the number of PV has similar manner with FFA in accordance to our previous works [7]. Both of SFA and FFA were measured in % of volume. For validation of the result here, we used standard method of titration of FFA, and GCMS for fatty acids identification for a certain palm oil.

Result and Discussion

Fig. 1 shows change of polarization and FFA number for several vegetable oils from different types and brands against time of expiration of each oil. The bullets indicates change of polarization (in °) and the squares represents FFA number (in % of volume) of each oil. It can be concluded that the change of polarization has considerably increased with increasing time of expiration. And at the other hand, the FFA number does not have tendency with increasing time of expiration. It means that that polarization increases with degradation of oil quality until its expiration date, while the FFA test does not. In agreement with the previous study [2-3, 6-7] the polarization can be used directly to indicate oil quality level. Higher polarization indicates lower oil quality level. In case of expiration, it seems that polarization test better than standard test such as FFA test.

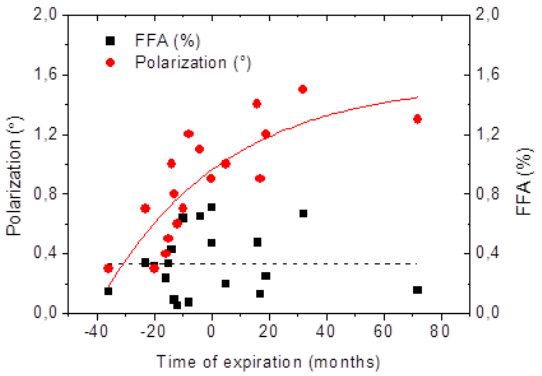

Fig. 1 change of polarization and FFA of vegetable oils for various time of expiration (in months). The sample is various vegetable oil from different brands. The time expiration more than 0 month indicates that the oil is already expired.

In Fig. 2, change of polarization is substantially dependent on time of expiration for a certain palm oil (the same brand but different time of expiration). It shows again that FFA number is indirectly influenced by time of expiration.

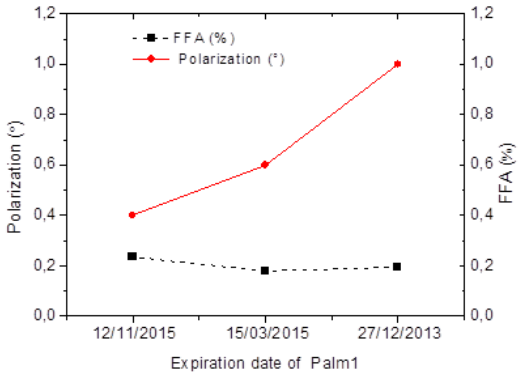

Fig. 2, the FFA (in % volume) and change of polarization (°) of palm oil from brand 1 (palm1) for three different expiration date.

Now what is most responsible for the increase of polarization for longer time of expiration? We have proposed that this causes by formation of SFA gradually. For the reason, we have checked how dependent the polarization on number of SFA is (fig. 3).

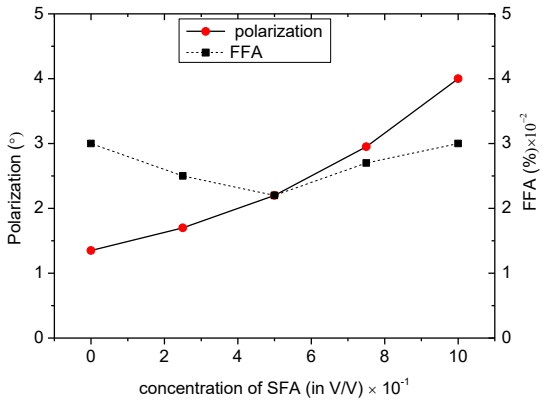

Fig. 3, change of polarization and FFA number against concentration of SFA (in part of volume). The solid Lines and dashed lines represent change of polarization and FFA number, respectively.

The SFA has been obtained by adding animal fats in a certain palm oil based on assumption that animal fats contains high SFA, which in turn a number of concentration of fats is proportional to concentration of SFA. At this point, we have suspected that any expired or degraded oil quality would be always accompanied by addition of new SFA formation. This will be very clear if any oil is exposed by external disturbance gradually. What's happened when the sample is well sealed and protected which therefore obtains minimal expose? It is usually found that a new SFA formation in oil is neglected if it is well protected from any treatment. Would be there any new addition of SFA formation in expired oil or in a degraded quality-oil? Yes there will be, however recently experience shows that it is very low in concentration. To explain it, we took certain samples such as palm 1 and palm 2 (same kind of oil but different quality) and examined using GCMS instrument. Table 2 are GCMS data for palm 1 and palm 2. We choose only highest fraction fatty acids (in form of SFA or UFA) that are usually found in palm oil. The SFA and UFA are indicated by C17:0 or C19:0 and C19:2 or C19:1, respectively.

Table 2 GCMS data for palm 1 and palm 2, its expiration date, and the highest fraction of SFA and UFA. The GCMS was taken in 18 June 2015.

Sample	expiration date	Fraction of Fatty acids				Change of polarization (°)
		C17:0	C19:2	C19:1	C19:0	
Palm 1	25/10/ 2014	0,3602	0,099	0,4273	0,0329	0,6
Palm 2	16/02/ 2017	0,3523	0,1061	0,4112	0,0336	0,5

At table 2, the C17:0, C19:2, C19:1, and C19:0 fatty acids represent methyl palmitate ($C_{17}H_{34}O_2$), methyl linoleate ($C_{19}H_{34}O_2$), methyl oleate ($C_{19}H_{36}O_2$), methyl stearate ($C_{19}H_{38}O_2$), respectively. A new formation of SFA or UFA is not observable in GCMS data or better it can be neglected. For both condition in table 1, it has shown that expired oil (palm 1) has always higher change of polarization than the edible one (palm 2). The data explains that a new addition of SFA is hardly existed or it is in very low concentration. The expired oil contains more SFA of C17:0 but less SFA of C19:0 than the edible one. The UFA distribution also shows more C19:1 in expired oil than in edible one.

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It is therefore described that both SFA and UFA represented by C17:0 and C19:1 would play important role to increasing polarization. Their high fraction apparently should contributed to change of polarization, as well.

Summary

The simple light polarization shows more powerful preliminary test for quality level of various edible oil than standard test such as FFA test, and indeed it can differentiate edible oils and expired oils. High change polarization in expired oil or in degraded quality-oil does not mean that there is a new addition formation in high number of SFA. It would be preferred by high number of SFA and UFA combination, in this case for palm 1 and palm 2 represented by C17:0 (Methyl palmitate) and C19:0 (Methyl oleate).

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