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Study of Crude Palm Oil (CPO) Handling and Storage Process in Palm Oil Mills in an Effort to Improve CPO Quality and Reduce the Risk of Contaminants Formation

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Abstract: Crude Palm Oil (CPO) is palm oil obtained from the extraction or compression process of oil palm fruit flesh and has not been purified. Palm oil is usually used for food, cosmetic industry, chemical industry, and animal feed industry. Increasingly open insight and increasing consumer awareness of the importance of food safety and quality assurance supported by technological developments and laboratory analysis methods, new types of contaminants in food products are also found. Currently, the Indonesian government is facing challenges regarding the issue of 3-monochloro-1,2-propanediol ester (3-MCPD Ester) and glycidyl ester (GE) in palm oil which can hamper Indonesia's palm oil trade in the future. The aim of this research to modify the pumping time and storage time of CPO from Reclaimed tank to (Vertical Clarifier Tank) VCT. The study demonstrated that the length of time for pumping CPO from reclaimed tanks to VCT and the length of time for CPO storage up to 20 days had a significant effect on the quality of ALB, PV, DOBI and DF.

Keywords: Crude Palm Oil, Free Fatty Acid, Peroxide Value, Deterioration of Bleachability Index, Discriminant Function

1. INTRODUCTION

Crude Palm Oil (CPO) is palm oil obtained from the extraction or compression process of oil palm fruit flesh and has not been purified. However, before CPO is used as food, it must first go through a purification process [1]. CPO is an oil synthesized in palm fruit so that it is 22-24 weeks after fertilization. CPO is extracted from the mesocratic part of the palm fruit mechanically and physically in the palm oil factory, namely the liquid and solid fractions caused by triglycerides containing the main components of palmitic and oleic acids with a balanced composition[2].

Currently, the Indonesian government is facing challenges with the issue of 3-monochloro-1,2-propanediol ester (3-MCPD Ester) and glycidyl ester (GE) in palm oil which can hamper Indonesia's palm oil trade in the future. These 3-MCPD and GE compounds consist of 3-MCPD monoester and 3-MCPD diester which have the potential to be hydrolyzed by lipase enzymes. The precursor for the formation of 3-MCPD esters and GE is the content of free fatty acids (FFA), which is correlated with the content of Diacylglycerol (DAG). The formation of 3-MCPD ester and GE involves the formation of acyloxonium ions from triacylglycerol (TAG), diacylglycerol (DAG), and monoacylglycerol (MAG). The acyloxonium ion then reacts with the chloride ion to form 3-MCPD Esters and GE [3].

Based on the explanation above, it is deemed necessary to conduct research with the aim of evaluating several quality parameters of CPO and their changes related to the risk of formation of 3-MCPD ester and GE contaminants in refinery as well as oxidative stability and color stability of palm oil derivatives in palm oil mills. The length of waiting time for CPO quoted back in the reclaimed tank or pumping time of CPO quoting results into VCT is estimated to affect the quality of mixed CPO and also the oxidative stability of CPO.

This study aims to examine the effect of waiting time or pumping time for CPO from reclaimed tanks to VCT on the quality and stability of CPO during storage. Mixing of CPO from reclaimed tanks and VCT is simulated in the laboratory which is then analyzed for CPO quality parameters which include FFA content, peroxide value (PV), deterioration of bleachability index (DOBI), and discriminant function (DF) within a certain storage period to look at the oxidative stability of CPO. Based on the CPO quality parameter values mentioned above, the ease of refining CPO in the refinery and the risk of formation of 3-MCPD Ester and GE contaminants can be predicted.

2. MATERIAL AND METHODS

2.1. Material

The material used in this study is crude palm oil from the Sawit Seberang palm oil mill, PT. Nusantara II District, Langkat Regency, North Sumatra.

2.2. Tools

The equipment used in this study were 1000 g analytical balance, 250 ml erlenmeyer, volume pipette, measuring cup, UV-1800 spectrophotometer, 10 mm cuvet quarts, 25 ml volumetric flask, hot plate, 250 ml beaker glass, 250 ml erlenmeyer, 50 ml and 100 ml measuring cups, 50 ml burette, sample bottle, 60 mm glass funnel, 0.5 ml dropper volume.

2.3. Analysis of the free fatty acid prosedur

Weight 10 g of sample into a 250 ml Erlenmeyer flask, add 25 ml of neutral 95% alcohol and for 10 minutes on a hot plate while stirring, titrate with 2 ml of indicator PP. The mixture is shaken and titrated with 0.1 N NaOH solution until a pink color appears and does not disappear for 30 seconds.

$$\text{Free Fatty Acid} = \frac{\text{ml of NaOH} \times \text{N NaOH} \times 25.6}{\text{massa, g of sample}}$$

Where : (ml of NaOH=Volume of titrant), (N NaOH=Normality of NaOH), (25.6=BM asam palmitate)

2.4. Analysis of the Peroxide Value

Weight 5 g of sample into a 250 ml Erlenmeyer flask, then 30 ml of a mixture of glacial acetic acid and chloroform (3:2) is added and 0.5 ml of saturated potassium iodide solution is added. The flask with the solution was then shaken for 1 minute until homogeneous. After 1 (one) minute since the addition of potassium iodide, added 30 ml of distilled water and 1-2 ml of 1% starch indicator, then shaken again until homogeneous. After homogeneous, the solution was titrated with 0.1N sodium thiosulfate until the solution turned clear.

$$\text{Peroxide Value} = \frac{(\text{S}-\text{B}) \times \text{N} \times 1000}{\text{massa,g of sample}} = \ldots \text{ meg/kg}$$

Where : (S=Volume of titrant, ml of sample), (B=Volume of titrant, ml of blank), (N=Normality of Potassium iodide)

2.5. Analysis of the Deterioritation of Bleachability Index

Analysis using Spektrometri UV-1800. Weight 10 g sample into a 250 ml Erlenmeyer flask, add Isooctane solution to the limit of the reading line. The sample to be analyzed was inserted into the cuvette approximately the upper limit of the cuvette, and analyzed is the absorbance 269 nm and 446 nm.

$$\text{DOBI} = \frac{A_{446}}{A_{269}}$$

Where : A_{446} = is the absorbance at λ446 nm, A_{269} = is the absorbance at λ269 nm

2.6. Analysis Discriminant Function

Equipments and apparatus as used in DOBI test and Veroxide Value test. Discriminant function is shown as below :

$$Y1\text{-}Y3 = 0.3X1 + 16X3 + 0.13X4 - 27.29$$

Where : (X1=Extinction of a 1 % solution at 259 nm), (X3=DOBI), (X4=PV)

3. RESULTS AND DISCUSSIONS

3.1. The effect of the length of time for pumping CPO from reclaimed tanks to VCT and the effect of storage time on FFA levels.

The data from the research conducted for the increase in FFA in each treatment of CPO pumping time from reclaimed tanks to VCT and storage time, can be seen in table 1.

Table 1. FFA values (%) obtained from the treatment time of pumping CPO from reclaimed tanks to VCT and storage time.

Storage Time	FFA Values				
	Time of Pumping				
	0 Hour	2 Hour	4 Hour	6 Hour	8 Hour
0 Day	3.1 ± 0	3.18 ± 0.07	3.20 ± 0.07	3.4 ± 0	3.65 ± 0.07
4 Day	3.2 ± 0.14	3.35 ± 0.21	3.6 ± 0	3.7 ± 0.14	4.05 ± 0.07
8 Day	4.3 ± 0.14	4.5 ± 0	4.85 ± 0.07	5.05 ± 0.07	5.55 ± 0.07
12 Day	4.85 ± 0.07	5.15 ± 0.07	5.6 ± 0	5.95 ± 0.07	6.2 ± 0
16 Day	5.7 ± 0.14	6.1 ± 0.14	6.2 ± 0	6.6 ± 0.14	6.85 ± 0.07
20 Day	7 ± 0	7.15 ± 0.07	7.2 ± 0	7.75 ± 0.07	8.25 ± 0.07

Note :
Data is the average result of 2 replications ± standard deviation

From the results of the study, the percentage of FFA values listed in table 1, if described in graphical form, can be seen in Figure 1 below.

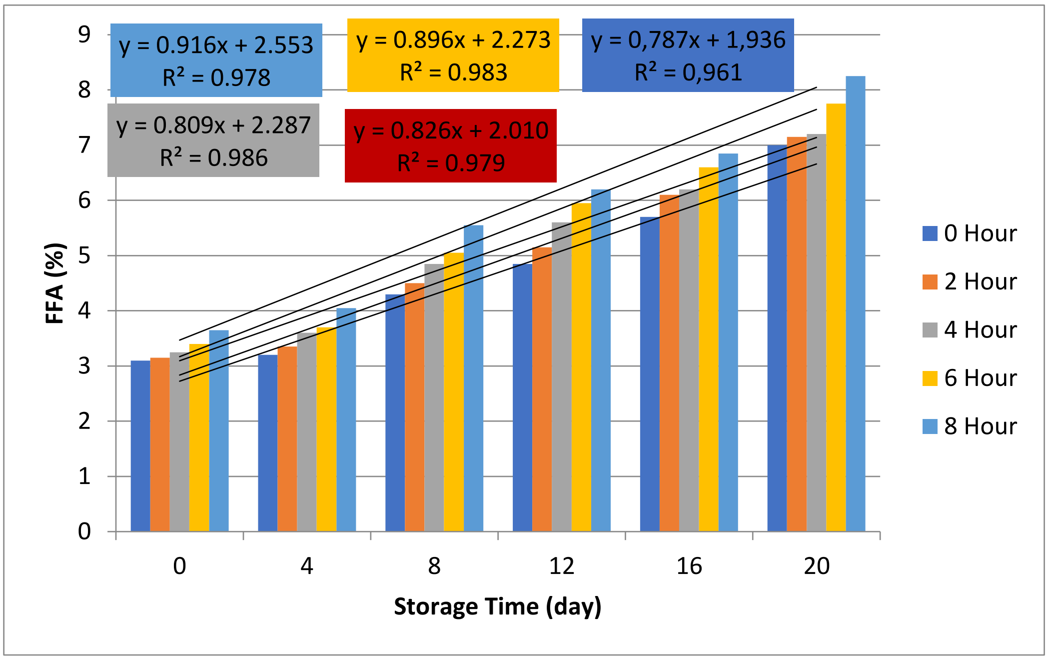

Figure 1. Changes in FFA value in CPO with CPO mixing treatment from reclaimed tanks with different pumping times to VCT and different storage times

Based on SNI 01-2901 in 2006, the maximum FFA level in CPO is 5%. From these data, it can be seen that the levels of FFA in the treatment of storage time 0 days with pumping time treatment of 0 hours to 8 hours are still in accordance with the established quality standards [4]. Furthermore, the FFA value in the treatment of storage time of more than 8 days with pumping time ranging from 0 hours to 8 hours has increased the FFA value >5% which is not in accordance with the established FFA quality standards. The increase in FFA during storage time and during pumping time can be caused by the hydrolysis process, in which 1 glycerol molecule and 3 FFA molecules will be produced.

FFA present in oils and fats have been present since the fruit has been harvested, and the amount will continue to increase during processing and storage. CPO quality will decrease if there is contamination by condensate in the sterilization unit, steam and heat injection in the digestion unit, high pressure in the oil oxidation press unit in the clarification unit, and excessive heating in storage [5]. The presence of FFA is usually used as an early indicator of damage to the oil. FFA that appears as a result of further hydrolysis can undergo oxidation reactions [6]. Thus, hydrolysis is a reaction that supports the oxidation reaction of the oil [7] .

During storage and heat treatment, oil will be subject to hydrolysis, oxidation, and polymerization processes which result in a decrease in quality and nutritional value [8]. It is known that there is a heat treatment on the storage of CPO in a tank with a temperature of 45ºC to maintain the viscosity of the CPO so that it is easy to pump further. Thermal oxidation of oil dominates the formation of hydroperoxides known as primary oxidation products which are then degraded into hydrocarbons, aldehydes, and ketones, and subsequently produce secondary oxidation products. Secondary oxidation products tend to be volatile and give off a rancid taste and odour in the oxidized oil [9].

3.2. The effect of the length of time for pumping CPO from reclaimed tanks to VCT and the effect of storage time on PV levels

Data from research conducted for changes in PV for each treatment of CPO pumping time from reclaimed tanks to VCT and storage time, can be seen in table 2. PV are related to the oxidative stability of the oil which is an important quality determinant parameter in natural oils produced. applied to food products. The oxidative stability of the oil is strongly influenced by the fatty acid composition and the content of minor components naturally present in the related oil. The higher the content of unsaturated fatty acids in the oil, the easier the oil will be damaged [10]. Furthermore, the initial quality condition of natural oil will also greatly affect its oxidative stability.

Table 2. PV values obtained from the treatment of CPO pumping time from reclaimed tanks to VCT and storage time

Storage Time	Pv values				
	Time of Pumping				
	0 Hour	2 Hour	4 Hour	6 Hour	8 Hour
0 Day	3.1± 0.14	3.15 ± 0.07	3.4 ± 0	3.55 ± 0.07	3.6 ± 0
4 Day	3.65 ± 0.07	3.8 ± 0	4.1 ± 0.14	4.1 ± 0.14	4.35 ± 0.07
8 Day	4.45 ± 0.07	4.65 ± 0.07	4.7 ± 0	4.85 ± 0.07	4.9 ± 0.14
12 Day	5.1 ± 0	5.15 ± 0.07	5.25 ± 0.07	5.45 ± 0.07	5.45 ± 0.07
16 Day	6.25 ± 0.07	6.4 ± 0.14	6.55 ± 0.07	6.7 ± 0.14	6.8 ± 0.14
20 Day	7 ± 0.14	7.2 ± 0	7.45 ± 0.07	7.7 ± 0.14	7.8 ± 0.14

Note:

Data is the average result of 2 replications ± standard deviation

From the results of the research, the PV values obtained in table 2, if described in graphical form, can be seen in Figure 2 below.

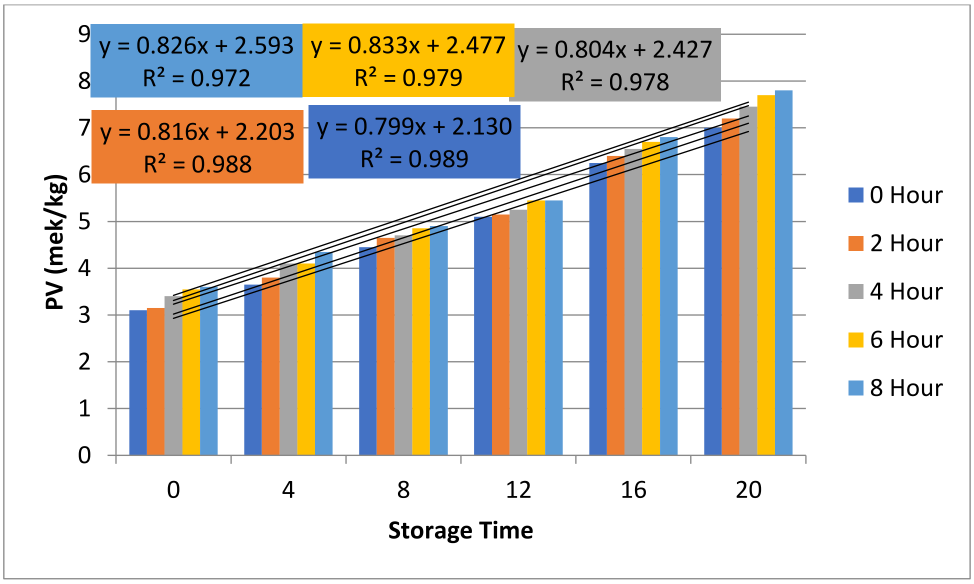

Figure 2. Changes in the PV value of CPO with CPO mixing treatment from reclaimed tanks with different pumping times to VCT and different storage times

According to Suroso (2013) that the recommended PV value for CPO is a maximum of 6 mek/kg [11]. From this research data, the storage time from 0 days to 12 days and pumping time from 0 hours to 8 hours is still in accordance with the standard. When viewed from the length of storage time >12 days starting from pumping 0 hours to 8 hours, the PV value is already above the standard value. This indicates that storage time has a higher effect than the pumping time of CPO from reclaimed tanks to VCT, although from table 2 data it can be seen that the PV value continues to increase along with the increase in pumping and storage time. In Figure 2 it can be seen that the pumping time and storage time affect the PV value. This is in accordance with the explanation of Gunawan et al (2003) that heating for a longer time can cause damage to the oil [12]. The heating process accelerates oxidation reactions, decomposition reactions of primary oxidation products, and hydrolysis reactions. An increase in PV levels is an indicator and a warning that soon it will smell rancid [13]. Thus, the stability, shelf life of the oil and the quality of the oil have decreased due to the increase in PV value [14].

3.3. The effect of the length of time for pumping CPO from reclaimed tanks to VCT and the effect of storage time on Deterioration of Bleachability Index *(DOBI) levels*

The results obtained showed a decrease in DOBI in line with an increase in the pumping time of CPO from reclaimed tanks to VCT and an increase in storage time, as can be seen in table 3.

Table 3. DOBI values obtained from the treatment of CPO pumping time from reclaimed tanks to VCT and storage time.

Storge Time	DOBI Values				
	Time of Pumping				
	0 Hour	2 Hour	4 Hour	6 Hour	8 Hour
0 Day	3.75 ± 0.07	3.65 ± 0.07	3.55 ± 0.07	3.6 ± 0	3.55 ± 0.07
4 Day	3.5 ± 0	3.45 ± 0..07	3.25 ± 0.07	3.15 ± 0,07	3.1 ± 0
8 Day	2.7 ± 0.14	2.65 ± 0.07	2.4 ± 0.14	2.4 ± 0	2.3 ± 0
12 Day	2.15 ±0.07	2 ± 0.14	1.85 ± 0.07	1.65 ± 0.07	1.4 ± 0.14
16 Day	1.3 ± 0	1.2 ± 0	0.95 ± 0.07	0.85 ± 0.07	0.75 ± 0.07
20 Day	0.45 ± 0.07	0.45 ± 0.07	0.35 ± 0.07	0.3 ± 0	0.2 ± 0

Note : Data is the average result of 2 replications ± standard deviation

From the results of the study, the DOBI value obtained in table 3, if described in graphical form, can be seen in figure 3 below.

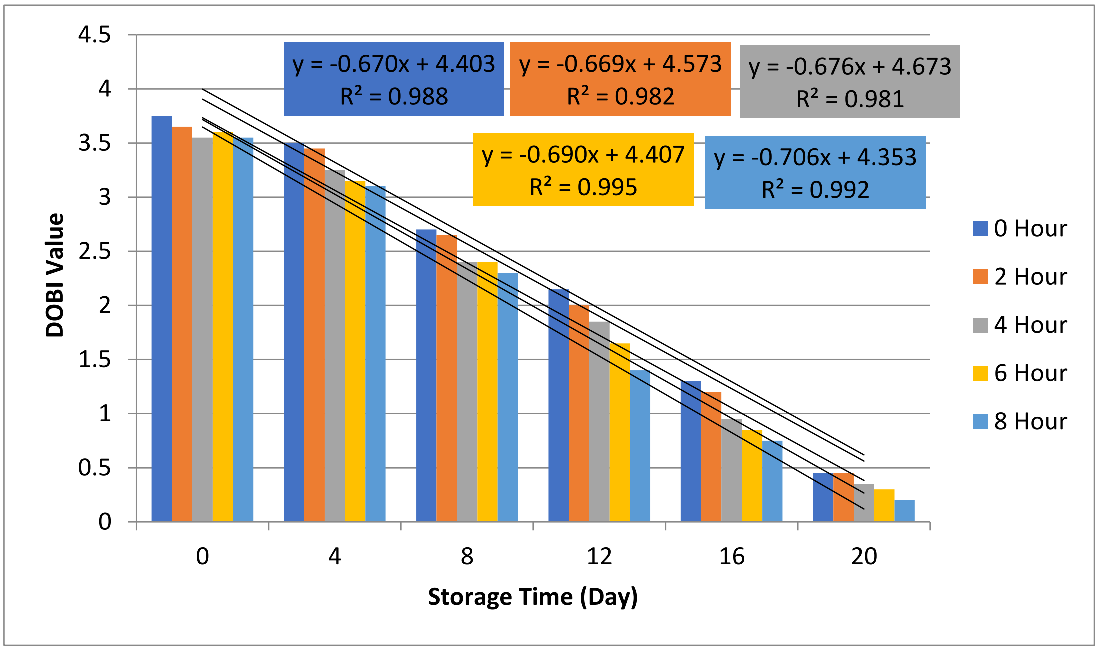

Figure 3. Changes in DOBI value in CPO with CPO mixing treatment from reclaimed tanks with different pumping times to VCT and different storage times

A high DOBI value will be obtained if the fruit processed in the palm oil mill is the right ripe fruit, because it contains high levels of carotene. In unripe fruit the DOBI value is low because the carotene content is also low, while in overripe fruit the DOBI value is low because the FFA level is high [15].

Although the DOBI value has not yet become a quality requirement for CPO, several companies have used DOBI for domestic and export trade. Hasibuan., (2012) reported that the average DOBI value in Indonesian CPO was 2.24 with a range of 0.9-2.99 [16]. In this study, the DOBI value at 0 days of storage up to 8 days of storage still met the standard. Refer from the research of quality of indonesian cpo before and some of standart recommended of dobi of cpo in SNI minimum of 2.2 and after a storage time of more than 8 days, the DOBI value of CPO was categorized as low-quality CPO. From table 3 it can be seen that the length of time for pumping CPO from reclaimed tanks to VCT affects the DOBI value during storage, where the DOBI value decreases with each pumping time and storage time. In addition, palm fruit that has been harvested should be processed immediately so that the quality of CPO is high [17].

The factors underlying the low DOBI value in this study were due to contamination of good quality CPO by mixing CPO from reclaimed tanks recovered from sludge palm oil. This practice of CPO recovery is often carried out by several companies in order to obtain high yields to meet targets without paying attention to the impact of the quality of the CPO.

3.4. Effect of length of time pumping CPO from reclaimed tank to VCT and effect of storage time on the value of Discriminat Function (DF)

The results obtained showed a decrease in DF in line with an increase in the pumping time of CPO from reclaimed tanks to VCT and an increase in storage time, as shown in table 4.

Table 4. DF values obtained from the treatment time of pumping CPO from reclaimed tanks to VCT and storage time.

Storage Time	DF				
	Time Of Pumping				
	0 Hour	**2 Hour**	**4 Hour**	**6 Hour**	**8 Hour**
0 Day	33.16 ± 1.11	31.57 ± 1.12	30.03 ± 1.16	30.00 ± 1.12	30.81 ± 0.01
4 Day	30.58 ± 1.12	29.00 ± 1.13	25.84 ± 1.14	24.25 ± 1.15	23.47 ± 0.00
8 Day	16.52 ± 2.27	15.81 ± 1.12	11.75 ± 2.26	11.77 ± 0.01	10.21 ± 0.01
12 Day	8.37 ±1.13	5.9 ± 2.27	3.59 ± 1.12	0.37 ± 0.52	0 ± 0
16 Day	0 ± 0	0.10 ± 0.14	0.05 ± 0.07	0 ± 0	0 ± 0
20 Day	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0

Note :
Data is the average result of 2 replications ± standard deviation

From the results of the research, the DF value obtained is in table 4, if it is described in graphical form, it can be seen in Figure 4 below.

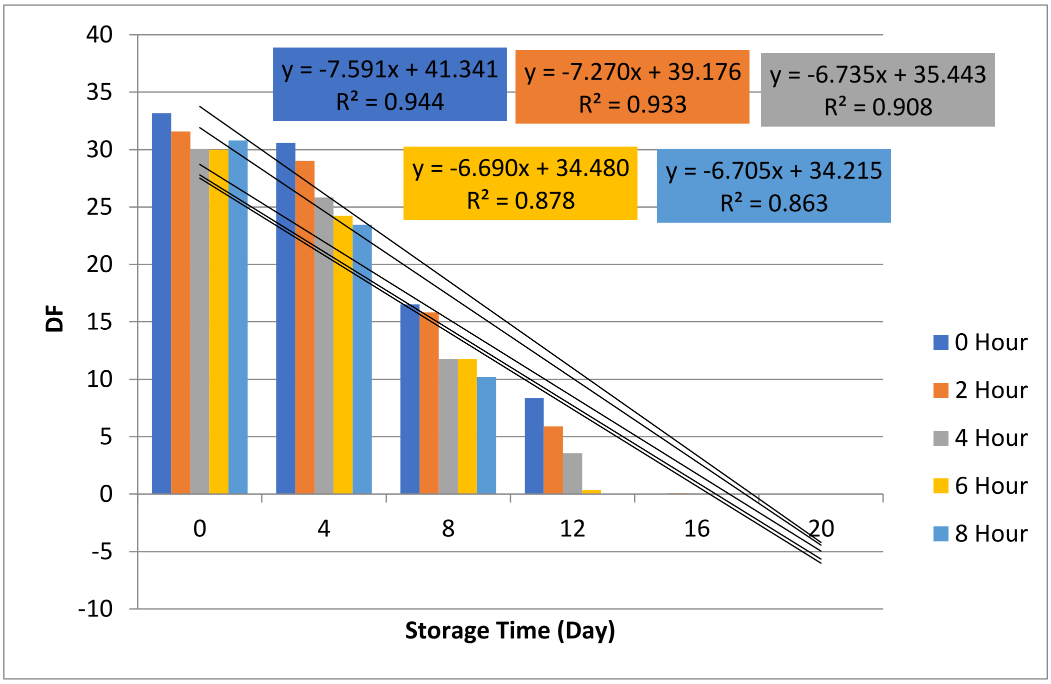

Figure 4. Changes in the value of DF in CPO with CPO mixing treatment from reclaimed tanks with different pumping times to VCT and different storage times.

The Oxidation because of heat, contamination of CPO which is obtained from sludge palm oil have decreased the quality of CPO such as DF value. The DF value is also influenced by the PV and DOBI values, when the PV value increases with pumping time and storage time and the DOBI value decreases with pumping time and storage time affects the DF value, so the DF value also decreases in this study. From the data in Table 4, it can be stated that if it is necessary to mix CPO from reclaimed tanks to VCT, pumping should be carried out a maximum of every 4 hours and storage can only be done for 4 days. It can be concluded that from each combination of the four treatments each has an effect on the FFA, PV, DOBI and DF values. So if it is still done mixing CPO from reclaimed tanks to VCT based on this study recommends that CPO should be pumped at <4 hours and CPO storage should be done <8 days in order to prevent the rate of damage or further degradation of CPO quality.

4. CONCLUSION

The length of time for pumping CPO from reclaimed tanks to VCT and the length of time for CPO storage of up to 20 days have a significant effect on the quality of FFA, PV, DOBI and DF. The combination of treatment time for pumping CPO from reclaimed tanks to VCT and CPO storage time of up to 20 days has a significant effect on the quality of FFA, PV, DOBI and DF. If the mixing of CPO from VCT and reclaimed tanks must be carried out, pumping should be carried out a maximum of once every 4 hours for storage time, it should only be carried out for up to 8 days before further processing in the refinery.

References:

1. Szydłowska-Czerniak A, Trokowski K, Karlovits G, Szłyk E. Effect of refining processes on antioxidant capacity, total contents of phenolics and carotenoids in palm oils. Food Chem. 2011;129(3):1187–92.
2. Gibon V, De Greyt W, Kellens M. Palm oil refining. Eur J Lipid Sci Technol. 2007;109(4):315–35.
3. Rahn AKK, Yaylayan VA. Monitoring cyclic acyloxonium ion formation in palmitin systems using infrared spectroscopy and isotope labelling technique. Eur J Lipid Sci Technol. 2011;113(3):330–4.
4. Lembar TA. " Hak Cipta Badan Standardisasi Nasional , Copy standar ini dibuat untuk penayangan di www.bsn.go.id dan tidak untuk di komersialkan " Lampiran A (normatif) Lembar penilaian sensori terasi udang. 2021;6.
5. Hamdan K, Abd Aziz S, Yahya A, Rokhani FZ, Steward BL. Detection of sludge contamination in crude palm oil using dielectric spectroscopy. Trans ASABE. 2015;58(2):227–32.
6. Gutiérrez F, Fernández JL. Determinant parameters and components in the storage of virgin olive oil. Prediction of storage time beyond which the oil is no longer of "extra" quality. J Agric Food Chem. 2002;50(3):571–7.
7. Choe E, Min DB. Mechanisms and factors for edible oil oxidation. Compr Rev Food Sci Food Saf. 2006;5(4):169–86.
8. Matthäus B. Use of palm oil for frying in comparison with other high-stability oils. Eur J Lipid Sci Technol. 2007;109(4):400–9.
9. Frankel EN. Chemistry of extra virgin olive oil: Adulteration, oxidative stability, and antioxidants. J Agric Food Chem. 2010;58(10):5991–6006.
10. Budijanto S, Sitanggang AB. Kajian Keamanan Pangan Dan Kesehatan Minyak Goreng. J Pangan. 2016;19(4):361–72.
11. Suroso AS. Kualitas Minyak Goreng Habis Pakai Ditinjau dari Bilangan Peroksida , Bilangan Asam dan Kadar Air. J Kefarmasian Indones. 2013;Vol 3(2):77–88.
12. Gunawan G, Aloysius MTM, Rahayu A. Analisis Pangan: Penentuan Angka Peroksida dan

Asam Lemak Bebas pada Minyak Kedelai dengan Variasi Menggoreng. J Kim Sains dan Apl. 2003;6(3):13–6.

13. Muhammadiyah U, Rahayu RRAN, Muhammadiyah U, Cardosh SR, Jakarta M. Pengaruh Massa Bioadsorben Dari Enceng Gondok Pada Proses. 2014;(November):1–5.
14. Onyema C, Ibe K. Effects of Refining Processes on the Physicochemical Properties of Some Selected Vegetable Oils. Am Chem Sci J. 2016;12(4):1–7.
15. Hasibuan HA. DETERIORATION OF BLEACHABILITY INDEX PADA CRUDE PALM OIL : BAHAN REVIEW DAN USULAN UNTUK SNI 01-2901-2006. 2016;2006.
16. Hasibuan HA. KAJIAN KARAKTERISTIK MINYAK INTI SAWIT INDONESIA DAN PRODUK Study on Characteristics of Indonesian Palm Kernel Oil and Its Fractionation Products. J Standarisasi. 2012;14(2):98–104.
17. Jusoh JM, Rashid NA, Omar Z. Effect of Sterilization Process on Deterioration of Bleachability Index (DOBI) of Crude Palm Oil (CPO) Extracted from Different Degree of Oil Palm Ripeness. Int J Biosci Biochem Bioinforma. 2013;3(4):322–7.

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