Jurnal Ilmu Pertanian Indonesia (JIPI), April 2022
ISSN 0853-4217
EISSN 2443-3462

Vol. 27 (2) 177−181
http://journal.ipb.ac.id/index.php/JIPI
DOI: 10.18343/jipi.27.2.177

Preprocessing Factors Affected Free Fatty Acid Content in Crude Palm Oil Quality

(Faktor-Faktor Prapengolahan yang Memengaruhi Kadar Asam Lemak Bebas pada Mutu Minyak Sawit Mentah)

Edyson, Fitrah Murgianto*, Adhy Ardiyanto, Erika Juli Astuti, Melina Putri Ahmad

(Diterima Mei 2021/Disetujui Maret 2022)

ABSTRACT

The quality of CPO (Crude Palm Oil) is determined by the Free Fatty Acid (FFA) with the standard value below 5%. High FFA in CPO will cause further difficulties due to low refining rate and quality like rancidness and odor. The objective of this research was to determine the factors that affect the FFA content in CPO. This research was conducted from January until April 2021. Fruit samples were collected from BKLE and PNRE East Kotawaringin and analyzed to Analytical Laboratory PT BGA. The FFA value was determined using the titration method according to Indonesian National Standard (SNI). Based on this research, several factors such as rat and moth attacks, fruit maturity, fruit handling, and delayed delivery to the palm oil mill affected the FFA value. These factors caused an increase in the FFA value up to 41.10%–204% compared to the average FFA value is only 0.77%–1.29%. Therefore, minimizing the pre-processing problem will reduce the potential of FFA value increment so that good quality CPO can be obtained.

Keywords: fruit handling, fruit maturity, pest attack, titration method

ABSTRAK

Kualitas CPO *(crude palm oil)* ditentukan oleh kadar asam lemak bebas (ALB) dengan nilai standar di bawah 5%. Kandungan ALB yang tinggi dalam CPO akan menyebabkan berbagai kerugian akibat rendahnya nilai pemurnian dan rendahnya kualitas seperti tengik dan bau. Penelitian ini bertujuan menentukan faktor-faktor yang memengaruhi kadar ALB pada CPO. Penelitian dilakukan pada bulan Januari sampai April 2021. Sampel buah diambil dari Kebun BKLE dan Kebun PNRE, Kotawaringin Timur, dan dianalisis di Laboratorium Analitik PT BGA. Nilai FFA diukur dengan metode titrasi menurut Standar Nasional Indonesia (SNI). Berdasarkan hasil penelitian, beberapa faktor seperti serangan tikus dan ulat pemakan buah kelapa sawit, kematangan buah, penanganan buah, dan keterlambatan pengiriman ke pabrik kelapa sawit memengaruhi nilai FFA. Faktor-faktor tersebut menyebabkan peningkatan nilai FFA hingga 41,10%–204% dibandingkan kondisi buah normal, yang hanya meningkat 0,77%–1,29%. Meminimumkan faktor-faktor prapengolahan akan mengurangi potensi peningkatan nilai FFA sehingga dapat diperoleh CPO yang berkualitas baik.

Kata kunci: kematangan buah, metode titrasi, penanganan buah, serangan hama

INTRODUCTION

Vegetable oil in the world comes from several plants such as oil palm, soybean, sunflower, and rapeseed. Among other oil crops, oil palm is the most efficient crop in oil production, land management, harvesting, and processing (Murphy 2014). Oil palm can produce two types of oil, namely crude palm oil (CPO) from fruit mesocarp and palm kernel oil (PKO) from palm kernel. Palm oil has been used for human consumption, and it has become a source of edible oil (Ali *et al.* 2012). The results of CPO derivatives through purification produce edible products such as cooking oil, margarine, and shortening. The cooking oil consumption in Indonesia reached 8.81 kg/capita/year in 2019. The projection of cooking oil demand is predicted to reach 9.94 kg/capita/year in 2022 (Kementan 2020).

The high market demand for cooking oil impacts the demand for crude palm oil both in terms of quantity and quality. Many factors determine the quality of palm oil and result in the oil price. The most frequent parameter is a free fatty acid (FFA) that has been concerned during production, storage, and marketing (Saad *et al.* 2007). The high content of free fatty acids in CPO will cause difficulties for the purification process to obtain quality derivatives (Japir *et al.* 2016). The high FFA value in CPO will cause its derivative products to get a high FFA value. The high value of FFA in its derivative products will undoubtedly be dangerous if used for human consumption (Bazina & He 2018). Cooking oil products with high FFA content will harm health, especially if reused (Goswami *et al.* 2015). The high FFA value of cooking oil contributed to several

Bumitama Gunajaya Agro Research Center, Palangkaraya, Indonesia 74354
* Coressponden Author:
Email: fitrah.murgianto@bumitama.com

diseases such as heart disease (Putri & Anggraini 2015), obesity that leads to insulin resistance, and type 2 diabetes. Consuming food with high levels of free fatty acid will increase the level of low-density lipoprotein (LDL), lower the level of high-density lipoprotein (HDL) of blood, and reduce the response to the hormone insulin (Boden 2003).

The quality of crude palm oil based on SNI 01-2901-2006, namely water and impurity content, iodine number, FFA level maximum of 0.5%, 50 g/100 g, and 0.5%, respectively (BSN 2006). Palm oil mills usually use an FFA value maximum of 5% as written in the Palm Oil Refiners Association of Malaysia (PORAM) standard; it is acceptable for trade purposes (Dewi *et al.* 2014). Processing at the palm oil mill and good condition of fresh fruit bunches (FFB) play an essential role in producing good oil (Tan *et al.* 2009). To achieve the standard CPO qualification, good production management before processing is needed. This research aims to determine the pre-processing factors that affect FFA levels in crude palm oil production.

MATERIALS AND METHOD

This research was conducted on Bangun Koling Estate (BKLE), Panaga Raya Estate (PNRE), and the Analytical Laboratory, Research Department, PT Bumitama Gunajaya Agro, Pundu Village, East Kotawaringin Regency, Central Kalimantan, Indonesia. The research was conducted from January to April 2021.

Field Sampling

Sample in this research was bunch spikelet and loose fruit. Sampling was carried out at various post-harvest factors: pest attack, ripeness level, handling, and delivery time. Pest attack was determined based on rat and oil-palm-bunch moth attacks on the fruit. The level of bunch ripeness is based on the amount of loose fruit before harvest, known as the minimum ripeness system standard (MRS). The level of fruit maturity consists of MRS1, MRS3, and MRS5, and each level has good and damaged conditions. The condition of good and damaged fruit was determined visually on the fruit. The good fruit condition was smooth without any bruise, while the damaged condition had the damaged more than 50% of the fruit. The MRS levels followed by a number indicate the amount of loose fruit before harvesting; the higher the number, the riper the fruit. Delayed delivery time was simulated purposely with immediate, one, three, and five hours after harvesting. After each sample reached the delaying time, it was continued to the processing step.

Handling factor was determined with fruit freshness and condition of loose fruit. The sampling of loose fruit freshness consists of fresh, half fresh, and rotten. Ten loose fruits were taken in each criterion, covering good and damaged conditions. Bunch and lose fruits are taken at the fruit collection point by predetermined criteria. The bunch samples were chopped right at the stalk to get spikelet, and ten spikelets were taken as the sample in each criterion. The spikelet sample was wrapped tightly in plastic and then carried carefully to the laboratory right away after sampling.

Laboratory Analysis

The FFA value analysis was carried out in the analytical laboratory of PT Bumitama Gunajaya Agro. Samples were dried using an oven at 105o C for 24 hours to reduce the moisture content. First, the FFA content was determined using the titration method described in SNI 01-2901-2006 (BSN 2006). Then, the percentage of FFA value was calculated using this equation:

$$\% \text{ FFA} = (25.6 \times N \times V)/W$$

Where:
N = Normality of sodium hydroxide
V = Volume of sodium hydroxide used
W = Weight of oil sample

RESULTS AND DISCUSSIONS

Post Harvesting Factors

The pests that generally attacks oil palm fruits are rats and oil palm bunch moth. Rat species mostly come from *Rattus tiomanicus* Miller (The Malayan Wood Rat), *Rattus argentiventer* Robinson & Kloss (The Rice Field Rat), and *Rattus tanezumi* (Temminck), while the oil palm bunch month is *Tirathaba mundella* Walker. The FFA values in the samples that were attacked by pests are shown in Table 1. The attacked fruit samples appear to have a higher FFA value than the healthy condition samples. FFA of fruit that rats attacked increased 43.41% compared to healthy conditions. Rats eat the flesh of the fruit flesh or mesocarp, which causes the injured fruit, as shown in Figure 1(a). The activity of eating rats and oil palm bunch moth caused injured to the fruit mesocarp palm oil. The remaining parts of the injured fruit increase the value of FFA due to exposure to air resulting in oxidation and hydrolysis (Ngando *et al.* 2006).

The highest increment in FFA value was shown in spikelets caused by the oil palm bunch moth. The FFA value increased up to 184% compared to the healthy sample. The higher FFA value was caused by oil palm bunch moth than rat attack. It might be due to bunch moth attacks in outer and inner fruit, while rat primarily attacks outer fruit only and cause more area of fruits to be damaged and exposed to the air. (Figure 1b). The more area of injury exposed to the air will increase

Table 1 Free fatty acid (FFA) values based on pest attack

Pest attack	FFA (%)
Rats	1.85
Oil palm bunch moth	3.67
Healthy	1.29

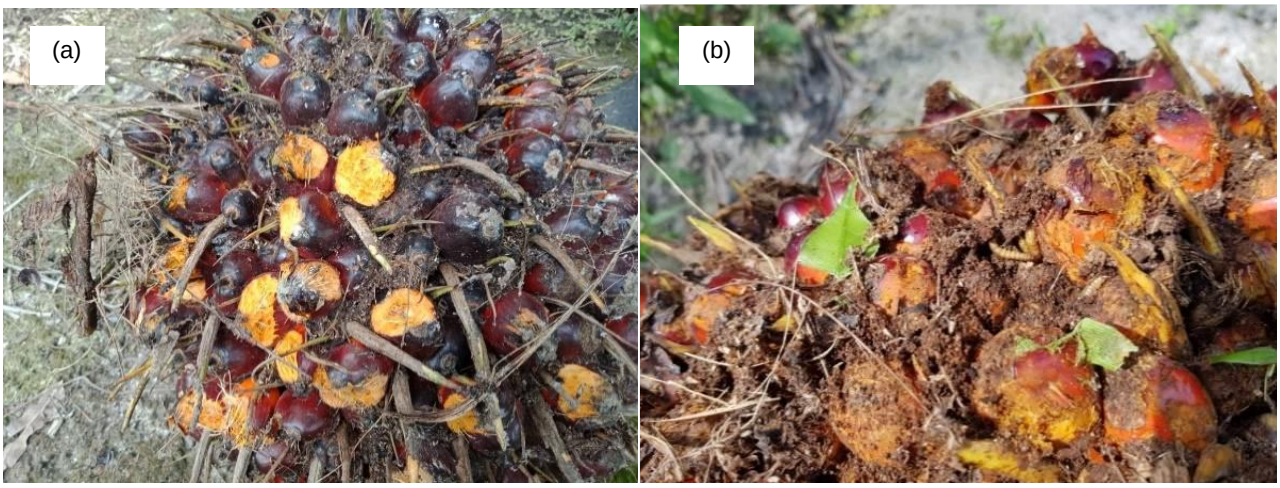

Figure 1 Pest attack on oil palm bunch (a) by rats and (b) by moths.

lipolytic enzyme production, thus increasing FFA value. The lipase enzyme activity increased the FFA value (Ruswanto *et al.* 2020). Another study found that 3-MCPD increased over time in the presence of lipase activity. Increment of FFA also was found to increase 3-chloropropan-1,2-diol (3-MCPD) ester. High exposure to 3-MCPD is considered to increase the risk for human health, so tolerable daily intake is suggested. This compound is classified as food contaminants with possible human carcinogens (Sudibyo & Lestari 2015). In addition to rat attacks and oil palm bunch moths, injury to oil palm fruit may be caused by other causes such as squirrel attacks and fruit harvesting activities. Injury to fruit is attempted to be as minimal as possible to suppress the increase in the FFA value in the CPO.

The higher FFA value was caused by oil palm bunch moth than rat attack (Table 1). It might be due to bunch moth attacks on outer and inner fruit and cause more area of fruits to be damaged and exposed to the air. Mainly rat attacks outer fruit only. Therefore, it is crucial to maintain the pest attack by rats and oil palm bunch moths to always be below the economic threshold so that the losses caused by these pests are still within tolerable limits.

The FFA values with ripeness level and condition are shown in Figure 2. In good and damaged conditions, the percentage of free fatty acid increased simultaneously on every ripeness level. The higher the level of ripeness, the greater chance of hydrolysis, which leads to FFA formation. The FFA level was observed significantly different and higher from under-ripe to over-ripe. FFA levels in fresh fruit bunch with loose fruit < 50 grains were 1.1%, 50–100 grains (2.5%), 100–200 grains (3%), and > 200 grains (4.6%) (Corley & Law 2001). The lowest FFA level was shown on MRS1 with good condition (0.77%), but an increase of 83.11% compared to the damaged condition (1.41%). The increment of FFA value from good to the damaged condition on the MRS3 and MRS5 was 87.61% and 129%, respectively. The process of harvesting oil palm fruit must be carried out at the right time when the oil palm fruit enters the optimum ripening

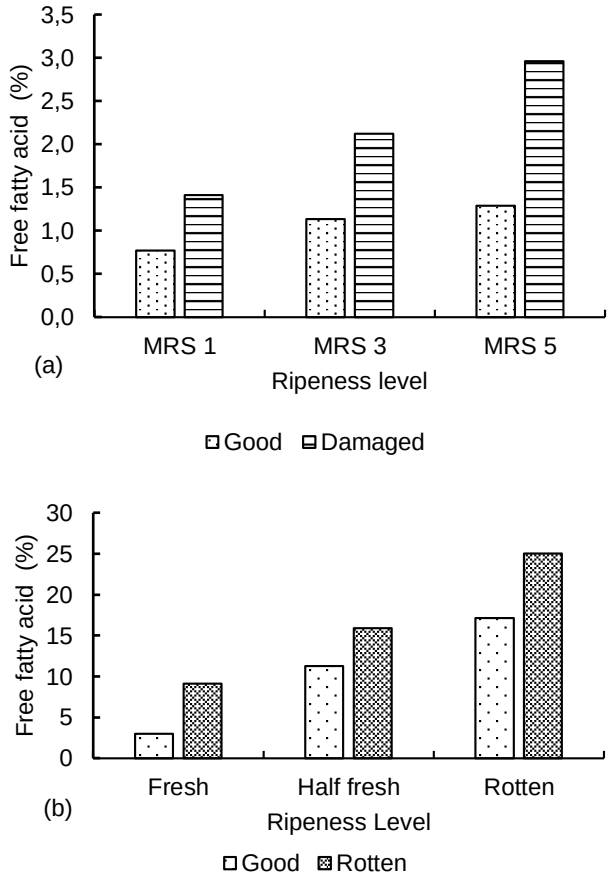

Figure 2 Comparison of Free fatty acid (FFA) level on good and damaged fruit condition in different (a) ripeness level and (b) fruit freshness.

phase. If the ripe palm fruit is harvested when it has passed the optimum ripe phase, marked by the number of loose fruits, then the resulting CPO will have a high FFA content.

The value of FFA in samples of several types of freshness and condition is shown in Figure 2(b). The highest FFA value was shown from rotten and damaged fruit (Figure 3a), and the lowest was fresh and good fruit (Figure 3b). After the fruit damage, the

FFA value increased 41.10%, 45.97%, and 204% in half fresh, rotten, and fresh fruit, respectively (Figure 2b). The FFA value of fresh fruit, both in good and damaged conditions, was lower than half fresh and rotten fruit. Rotten fruit can occur due to poor handling (delays in harvesting and delays in sending fruit to the mills) and pest and disease attacks. Poor fruit handling will cause many loose fruits to be not collected and left in the field for the next or couple of harvesting rounds (Sharif *et al.* 2017). Poor handling also increases the chance to damage the fruit. Mesocarp lipase is one of the lipid-related enzymes active upon abscission of the fruit and bruised (Sambanthamurthi *et al.* 2000). Therefore, immediate processing after harvest is needed to inactive the lipase to prevent the increment of FFA value (Ngando *et al.* 2006).

Palm oil comprises unsaturated and saturated fatty acids (Ulfah *et al.* 2016). Saturated fatty acids components mainly are palmitic C16 (44%), while the unsaturated fatty acids are oleic C18:1 (37%) and linoleic C18:2 (9%) (Ali *et al.* 2012). The FFA will be formed along with hydroperoxide when unsaturated fatty acids are oxidized, significantly when damaged. Hydroperoxide will covert to aldehyde and cause a rancid flavor and odor (Ruswanto *et al.* 2020).

Delivery Time

Following the fruit harvesting and placing in the fruit collection point by the harvester, the fruit is then sent to the mills. Delivery to the mills using a truck that picks up the fruit at each fruit collection point. It causes differences in each harvested oil palm's delivery and processing times. The value of FFA at different delivery and processing times is shown in Figure 4. The relationship between time and FAA is highly correlated with Pearson correlation value was 0.93, and the value of determination R2 was 0.87. The regression equation for this relationship was y = 0.724 + 0.32 x, where y =

FFA value (%) and x = delayed processing hours. The longer the delivery time and processing of oil palm bunches will increase the FFA value. The FFA value will increase naturally after the oil palm bunches are harvested, even in bunches with good conditions. Respiration and physiological activities of harvested fruit bunches still undergo after the bunch harvested, chemical content of palm oil in the mesocarp still can change. Long processing delay extends fruit to contact between air and water and produces high FFA due to high lipase enzyme activity that accelerated the oil hydrolysis process (Ruswanto *et al.* 2020). Labor arrangements, transportation, and road conditions are

Figure 3 Fruit freshness and condition: (a) rotten and damaged and (b) fresh and good.

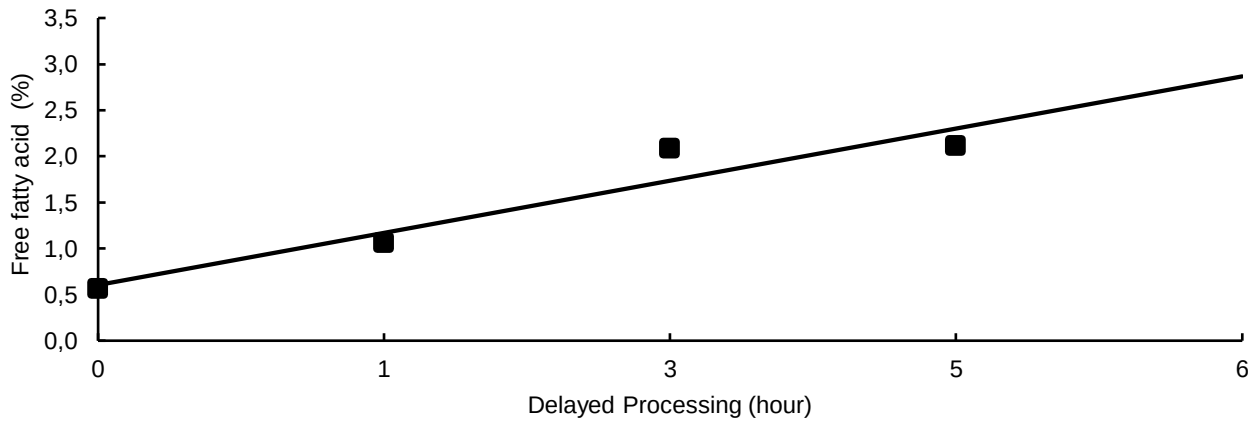

Figure 4 Relationship between delayed processing times and free fatty acid (FFA) values.

critical that the harvested palm oil fruit can be delivered directly to the mill on the same day after harvest.

CONCLUSION

Rat and bunch moth attacks increase FFA value up to 43% and 184%, respectively. Preventing any further loss with integrated pest management is suggested. The right level of maturity and good fruit handling will prevent any increment of FFA value. Delayed delivery to the processing after harvesting will increase FFA value even with proper handling due to the natural process. Immediate processing is expected to minimize FFA increment.

ACKNOWLEDGMENTS

The authors thank the Management of Bumitama Gunajaya Agro for their support in carrying out this research.

REFERENCES

Ali FS, Shamsudin R, Yunus R. 2014. The effect of storage time of chopped oil palm fruit bunches on the palm oil quality. *Agriculture and Agricultural Science Procedia*. 2: 165–172. https://doi.org/10.1016/j.aaspro.2014.11.024

Badan Standardisasi Nasional. 2006. SNI 01-2901-2006. BSN. Jakarta (ID).

Bazina N, He J. 2018. Analysis of fatty acid profiles of free fatty acids generated in deep-frying process. *Jounal of Food Science and Technology*. 55(8): 3085–3092. https://doi.org/10.1007/s13197-018-3232-9

Boden G. 2003. Effects of free fatty acids (FFA) on glucose metabolism: significance for insulin resistance and type 2 diabetes. *Experimental and Clinical Endocrinology and Diabetes*. 111(3): 121–124. https://doi.org/10.1055/s-2003-39781

Corley RHV, Law IH. 2001. Ripening, harvesting and oil extraction. *The Planter.* 77(906): 507–524.

Dewi LC, Susanto WH, Maligan JM. 2014. Penanganan pasca panen kelapa sawit (penyemprotan dengan natrium benzoat dan kalium sorbat terhadap mutu cpo). *Journal of Food Technology*. 3(2): 489–498.

Goswami G, Bora R, Rathore MS. 2015. Oxidation of cooking oils due to repeated frying and human health. *International Journal of Science, Technology and Management.* 4(1): 495–501.

Japir AA-WMM, Salimon J, Derawi D, Bahadi M, Yusop R. 2016. Purification of high free fatty acid crude palm oil using molecular distillation. *Chemistry: An Asian Journal*. 28: 2549–2554. https://doi.org/10.14233/ajchem.2016.20095

Kementerian Pertanian. 2020. Buletin Konsumsi Pangan. Kementan.

Murphy DJ. 2014. The future of oil palm as a major global crop: opportunities and challenges. *Journal of Oil Palm Research*. 26(1): 1–24.

Ngando Ebongue GF, Dhouib R, Carrière F, Amvam Zollo PH, Arondel V. 2006. Assaying lipase activity from oil palm fruit *(Elaeis guineensis* Jacq.) mesocarp. *Plant Physiology and Biochemistry.* 44(10): 611–617. https://doi.org/10.1016/j.plaphy.2006.09.006

Putri SR, Anggraini DI. 2015. Obesitas sebagai faktor resiko peningkatan kadar trigliserida. *Jurnal Majority*. 4(9): 78–82.

Ruswanto A, Handono Ramelan A, Praseptiangga D, Bagus Banyuro Partha I. 2020. Effects of ripening level and processing delay on the characteristics of oil palm fruit bunches. *International Journal on Advanced Science Engineering and Information Technology*. 10(1): 389. https://doi.org/10.18517/ijaseit.10.1.10987

Saad B, Ling CW, Jab MS, Lim BP, Ali ASM, Wai WT, Saleh MI. 2007. Determination of free fatty acids in palm oil samples using non-aqueous flow injection titrimetric method. *Food Chem*istry 102(4): 1407–1414. https://doi.org/10.1016/j.foodchem.2006.05.051

Sharif ZBM, Taib NBM, Yusof MSB, Rahim MZB, Tobi ALBM, Othman MSB. 2017. Study on handling process and quality degradation of oil palm fresh fruit bunches (ffb). *IOP Conference Series: Materials Science and Engineering*. 203. https://doi.org/10.1088/1757-899X/203/1/012027

Sambanthamurthi R, Sundram K, Tan Y. 2000. Chemistry and biochemistry of palm oil. *Progress in Lipid Res*earch 39(6): 507–558. https://doi.org/10.1016/S0163-7827(00)00015-1

Sudibyo A, Lestari N. 2015. Kajian keamanan pangan senyawa ester 3-MCPD dalam produk minyak/lemak pangan dan produk pangan lainnya. *Warta Industri Hasil Pertanian*. 32(01): 16–23.

Tan C-H, Ghazali HM, Kuntom A, Tan C-P, Ariffin AA. 2009. Extraction and physicochemical properties of low free fatty acid crude palm oil. *Food Chem*istry. 113(2): 645–650. https://doi.org/10.1016/j.foodchem.2008.07.052

Ulfah M, Riswanto A, Ngatirah N. 2016. Characteristics of oil blends from red palm oil and palm kernel olein. *Agritech.* 36(02): 145. https://doi.org/10.22146/agritech.12858