The Potential and Characterization of Oil Palm Loose Fruits (Lf) by Steaming and Pressure Steaming (Autoclaving) Process

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Abstract. Generally the palm loose fruits (LF) that have passed the processing time are considered as solid waste. In this study, the potential of palm loose fruits (LF) will be investigated. Mechanical extraction to obtain crude palm oil (CPO) from palm loose fruits (LF) will be carried out. Before enter the extraction process, oil palm loose fruits (LF) will be softened by heating using steaming or pressure steaming (autoclaving). The oil palm loose fruits (LF) that have passed the processing delay of 4, 8 and 12 days will be characterized and investigated related to the composition of the mesocarp, seeds and yields, both by steaming and autoclaving. It was found that the composition of mesocarp of oil palm loose fruits (LF) at different processing delay by steaming or autoclaving process was ± 55% and the yield of oil (CPO) was around 15.3 - 16.64%. The results also showed that autoclaving will give significantly more yields than steaming when the oil palm loose fruits (LF) had a 12-day delay in processing. The composition of the seeds or kernels of oil palm loose fruits (LF) was around 45%. Seeds known as kernels which can be processed to produce crude palm kernel oil (CPKO), further could offer the added economic value of palm loose fruits (LF). In addition, this study found that CPO of oil palm loose fruits (LF) contain palmitic acid, while palmitic acid increased with increasing processing delay of palm loose fruits. The palmitic acid content increases due to the hydrolysis process of the palm loose fruits. Palmitic acid is a type of saturated fatty acid that has similarities with hydrocarbon compounds found in petroleum, so it can be determined that oil palm loose fruits (LF) that have passed the processing time up to 12 days still have potential as a source of biofuels.

Keywords: Biofuels · characteristics of palm loose fruits · CPO extraction · palmitic acid

1 Introduction

Oil palm is tropical plant species which is originating from West Africa. Oil palm has the highest oil content compared to other vegetable oil crops, while each hectares of land could produce around 2.9 tonnes of palm oil. If we compare crops in terms of their

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yields, oil palm produces about four times higher than sunflower or rapeseed oil and about fifteen times higher than coconut or groundnut oil [1]. Due to its high oil content, oil palm is further developed and cultivated in Asia and Central America, while the largest palm oil producing countries in the world are Indonesia, Malaysia, Thailand, Colombia, Nigeria [2]. Indonesia is one of the largest palm oil producing countries in the world and in 2021, it was reported that Indonesia's palm oil production reached 46,223.3 thousand tons (Central Bureau of Statistics. 2022). In Indonesia, the palm oil industry plays an important role as a fairly large foreign exchange contributor, therefore, the palm oil industry plays a role in maintaining the health of Indonesia's trade balance. That foreign exchange obtained from exports of palm oil (CPO) and its derivative products as well as savings in diesel imports due to the biodiesel substitution program (Fatty Acid Methyl Ester) which is produced from domestic palm oil [3].

Oil palm fresh fruit bunches or known as FFB are the mainstay products of oil palm plantations. The Oil palm fresh fruit bunches (FFB) will be processed by a palm oil processing mill into palm oil or crude palm oil (CPO). The crude palm oil (CPO) is then processed into a variety of derivative products in various industries such as the food, energy and cosmetics and cleaning products. In the energy industry, CPO is processed into biodiesel, gasoline and avtur [4]. Currently, the world is starting to shift towards new and renewable energy due to the depletion of fossil energy sources while energy needs are increasing. The Indonesian government also encourages the transition to renewable energy program with one of the strategies being the B-30 policy, where the Indonesian government requires all diesel fuel in Indonesia to have a mixture of at least 30% biodiesel and 70% diesel. This policy is supported through Indonesia as the third-ranked biofuel producer in the world after the United States and Brazil, with an average biofuel produced of 126,000 barrels. In Indonesia, biofuel production is dominated by biodiesel produced from crude palm oil. Meanwhile, crude palm oil is also a source of raw materials for the food industries. The increasing of the global energy demand lead to an increase the demand of biodiesel, gasoline or palm oil-based avtur. Hence, it can create a competition between food and energy, therefore the use of non-food raw materials as an energy source is one solution.

In oil palm plantations, besides oil palm fresh fruit bunches (FFB), there are oil palm loose fruits (LF). Oil palm loose fruits are generally a sign indicating that the palm fruit on the tree is ripe and ready to be harvested. Oil palm loose fruit is a fruit that is released from the bunch and falls on the ground because the fruit is too ripe in the bunch. These fruits are scattered on the ground during harvesting activities. In general, if there are about 1–10 loose palm fruits on the ground, they indicate that the harvesting of oil palm fruit bunches can be started. Meanwhile, palm loose fruit are scattered in a radius of about 1.5–2.5 m from the visible FFB point. Oil Palm loose fruits (LF) are not attractive to be processed into crude palm oil by palm oil mills because it produces low quality of CPO with high free fatty acid content. Therefore, oil palm loose fruits are generally considered to be a solid waste, or some use them as crop fertilizers or mixtures for animal feed.

Oil palm loose fruits (LF) are estimated still containing oil, hence, the potential of oil palm loose fruits (LF) interest to be explored to increase its economic value. In this study, the potential of oil palm loose fruits (LF) will be explored. A mechanical extraction process will be carried out to obtain crude palm oil (CPO), but before the extraction process is carried out, the palm fruits are first softened by a heating with steam process. In this study, two kinds of process of softening palm fruits by steaming and pressure steaming (Autoclaving) will be analyzed. Furthermore, the character of crude palm oil of oil palm loose fruits (LF) produced by these two kinds of processes will be investigated.

2 Methods

2.1 Materials

Oil palm loose fruits (LF) obtained from palm oil farmers in Penajam, East Kalimantan was utilized in this study. The types of oil palm loose fruits (LF) are Dura and Tenera. The variation of delay processing time of the oil palm loose fruits (LF) used in this study were 4 days, 8 days and 12 days. Scales was used for weighing oil palm loose fruits (LF). Gas stoves, steam pans and autoclave were employed for the process of steaming oil palm loose fruits (LF). Mechanical press was used for extraction of softened palm fruits, and white calico cloth was used as a layer for the palm fruit press. Analytical digital scale and pycnometer were employed to analyze the density of the crude palm oil produced. Figure 1 shows the materials and tools were used.

2.2 Methods

In this study, the oil palm loose fruits (LF) at different process delay times, i.e. 4, 8 and 12 days were going to be softened by the steaming process. There were two kinds of steam processes, i.e. steaming and autoclaving. 1) Steaming process; this process was using a gas stove and a steaming pan. Firstly, the oil palm loose fruits (LF) were weighed and then steamed using a steaming pan for 1 h. Further, the oil palm loose fruits (LF) were separated from the seeds. The seeds and mesocarp (flesh of fruit) were weighed and recorded, then the mesocarp put in the mechanical press to extract the mesocarp to get crude palm oil (CPO). The oil came out from the mechanical press then it was collected, its volume was measured and its density was calculated. 2) In the autoclaving

Fig. 1. a) Oil palm loose fruits (LF), b) Steam pans, c) Autoclave, d) Mechanical press.

process, the temperature was carried out at 121 °C and at pressure of 0.2 bar for 15 min. The order of the process is the same as the steaming process, the difference is only in the equipment and steaming process time used for softening the fruits.

2.3 Research Parameters

The analysis were carried out to determine the character of crude palm oil (CPO) produced by extracted of mesocarp of oil palm loose fruits (LF). The analysis were carried out included: palm oil color (SNI 01–2901-2006-point 5.1), free fatty acid content (SNI 01–3741-2013), moisture content (SNI 01–2901-2006-item 5.2.1), dirt content (SNI 01–2901-2006-item 5.3), palmitate content (SNI 01–2901-2006- point 5.4) and iodine number (SNI 01–2901-2006-item 5.5).

3 Result and Discussion

In this study, the results of the extraction of oil palm loose fruits (LF) will be analyzed. Figure 2 shows crude palm oil (CPO) of oil palm loose fruits (LF) at different processing delay of 4, 8 and 12 days. The figure depicts that the color of CPO produced from oil palm loose fruits (LF) is reddish orange. The reddish color is due to the carotene content in the CPO of oil palm loose fruits (LF). Some literatures confirm that carotenoids are found in oil palm fruit. The color of CPO of oil palm loose fruits (LF) appeared redder with the increasing of processing delay of LF. This may be because the concentration of carotene increased along with the increasing of processing delay of oil palm loose fruits (LF).

In addition, the composition of the parts of oil palm loose fruits (LF) in the form of mesocarp (flesh of fruit) and seeds, also the yield of crude palm oil (CPO) were calculated.

Fig. 2. Crude palm oil (CPO) of oil palm loose fruits (LF) at different processing delay, i.e. 4, 8 and 12 days.

The character of CPO of oil palm loose fruits (LF) at different in the steaming process will be analyzed. Figure 3 describes the percentage of seeds and mesocarp (flesh of fruit) and the yield produced by the steaming and autoclaving (pressure steaming) process. Figure 3 explains that the composition of the seeds in the oil palm loose fruits (LF) is about 45% while the mesocarp is about 55%. From Fig. 3, it is shown that there is no significant effect on the yield obtained by steaming or pressure steaming (autoclaving). Addition, the yield of oil palm loose fruits (LF) on days 4 and 8 produced by steaming and pressure steaming (autoclaving) have no significant difference too. The yield of oil palm loose fruits (LF) of 4 and 8 days by steaming process is 16% ± 1.27 and by pressure steaming (autoclaving) is 16.64% ± 0.55. However, the yield of oil palm loose fruits (LF) of 12 days by pressure steaming process (autoclaving) is about 15.3%, it is higher than by steaming which the yield is about 11%. The oil palm loose fruits (LF) on day 12 wilted more than on day 4 and day 8. The fruits looked wilted because it was possible that the water content in the fruits had evaporated slightly. In the steaming process, the amount of oil yield produced depended only on the pressing process done by machine. While in the autoclave steaming, the temperature was 121 °C and pressure of 0.2 bar. The condition inside the pressurized steam pot allowed the water and oil in the mesocarp to come out of the fruit cells during the steaming process. Therefore, the oil yield increased during the fruit pressing process. Besides mesocarp which can be extracted to produce crude palm oil (CPO), the seeds also could be utilized to provide added economic value by extracted the seed cores to produce oil which known as crude palm kernel oil (CPKO) [5, 6].

Figure 4 describes the water contents and impurities in crude palm oil (CPO) from oil palm loose fruits (LF) extraction based on processing delays of 4 days, 8 days and 12 days

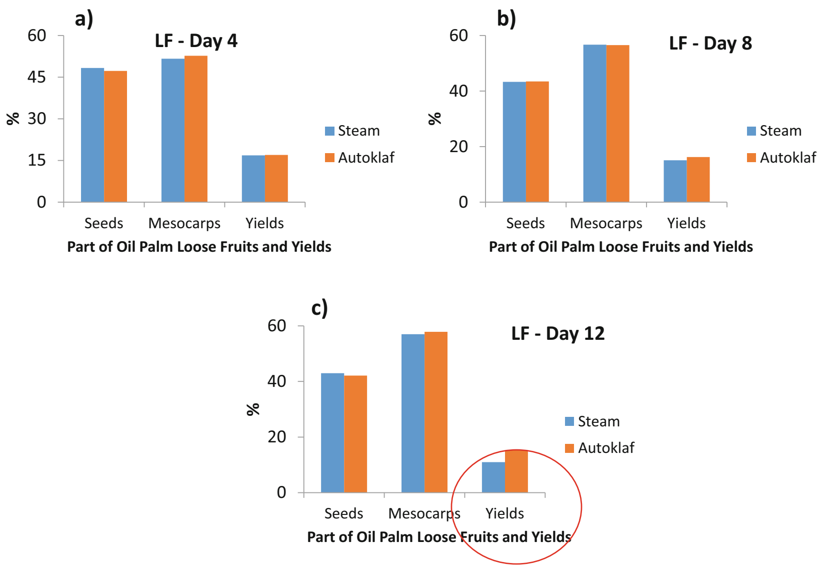

Fig. 3. Percentage of seeds, mesocarps and yields of oil palm loose fruits (LF) at different processing delay.

by steaming and autoclaving processes. In general, there is no significant difference of the impurity content between the steaming and autoclaving processes. The impurity level of crude palm oil is 45.36% ± 0.023. Impurities can be in the form of phosphatides, gums, waxes, coloring pigments, free fatty acids which also include phospholipids and glycolipids. Moisture content in the crude palm oil of oil palm loose fruits (LF) decreased with increasing processing delay time. This might be because some of the water in the palm fruit evaporated during the delay time of the process.

The moisture content of crude palm oil of oil palm loose fruits (LF) had a significant difference between the steaming and autoclaving processes. Figure 4 shows that the water content on days 4 and 8 by the autoclave process is lower than the steaming process. This is because the autoclave process provided an obstacle for water vapor to contact with palm fruits during steaming, so that no water entered into the fruits during the steaming process. However, the water content of crude palm oil with the autoclave process was greater than the steaming process on the 12 day. The explanation is that in general, the oil palm loose fruits (LF) after delay in the process will look wilted, this is due to the reduced water content in the palm fruit caused by natural evaporation over time. An autoclave is a steam pot equipped with pressure, so that water may come out of the cells of the fruits due to pressure inside the autoclave during the steaming process, hence, the extraction process had started during the autoclaving process [7]. Therefore, the volume of water will be higher during the pressing process.

Palmitic acid is a saturated fatty acid composed of 16 carbon atoms ($CH_3(CH_2)_{14}COOH$). It is one of the constituent fatty acids in oils and fats where this compound is similar to hydrocarbon compounds found in petroleum (Fessenden., 1986). From Fig. 5, it can be seen that the crude palm oil of oil palm loose fruits (LF) contains palmitic acid. Palmitic acid has a carbon atom similar to that of crude oil, so the resulted crude palm oil has the potential to be used as biofuel [8, 9]. Figure 6a shows

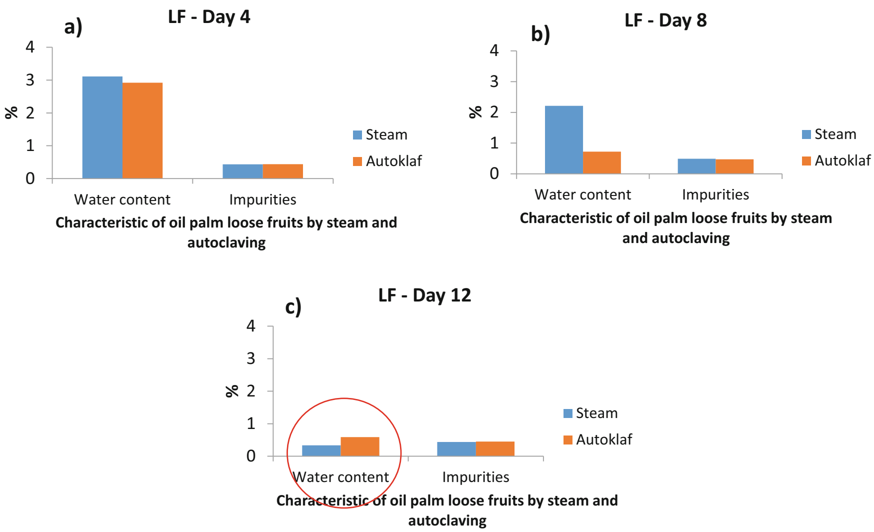

Fig. 4. Water content and impurities of oil palm loose fruits (LF) at different processing delay.

that the palmitic acid content increases with the increase in the delay time of the oil palm loose fruits (LF) processing. Palmitic acid is a fatty acid formed by the hydrolysis process. Naturally, in palm fruit there is a lipase enzyme [10]. The lipase enzyme has a function to break down fat or triglyceride molecules in palm oil, so that they become simpler molecules in the form of free fatty acids (FFA) [11].

Figure 6.a explains that the lipase enzyme continues to be active during the delay in the process of the palm fruits, the lipase enzyme works by hydrolyzing triglycerides [12, 13] into fatty acids, and one of which is palmitic acid. Figure 6b shows that the iodine number decreases with the increase in the delay time of the oil palm loose fruits (LF) processing. Iodine number is used to identify the unsaturation of an oil. The lower the iodine number in the oil interprets that the oil has a high unsaturation with increasing compounds that have double bonds. From Fig. 6b it explains that the longer the delay in the process will result in the lower the iodine number. It means that the oil has a higher level of saturation. This result is in line with Fig. 6a that the palmitic acid content which is a saturated fatty acid increases with the increase in processing delay of the oil palm loose fruits (LF).

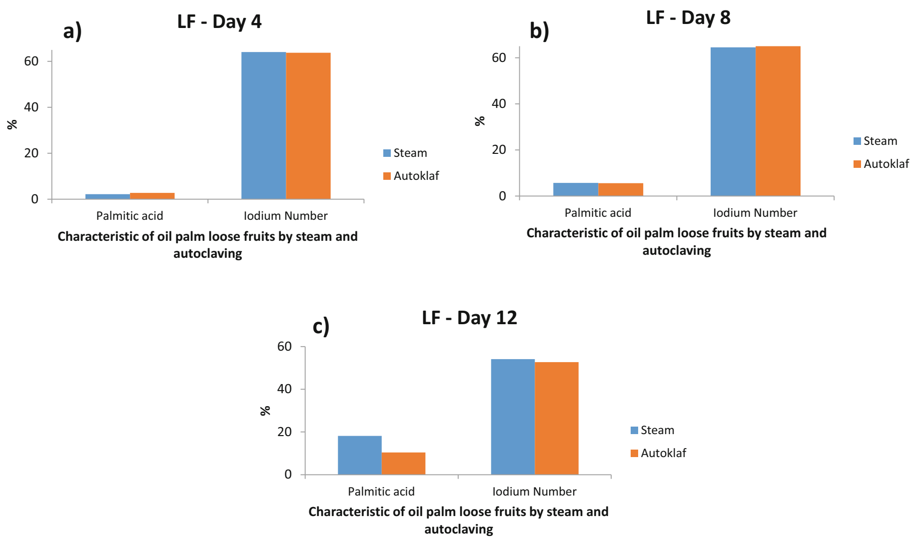

Fig. 5. Palmitic acid and Iodium Number of oil palm loose fruits (LF) at different processing delay.

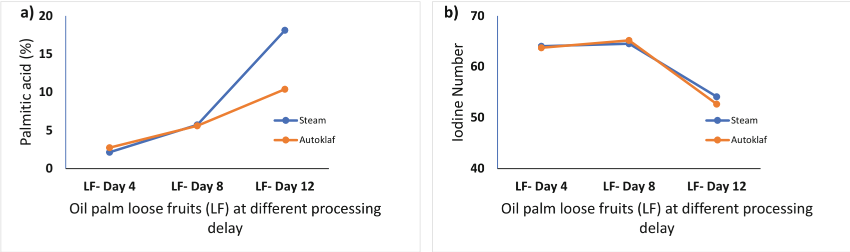

Fig. 6. The effect of processing delay on a) Palmitate acid content and b) Iodine number in steaming and autoclaving processes.

4 Conclusion

In this study, it was found that the color of crude palm oil (CPO) of the oil palm loose fruits (LF) was redder with the increasing of processing delay of the palm fruit (LF) due the concentration of carotene increased. Steaming for 1 h or autoclaving for 15 min can be used for softening the palm fruit before extracted by mechanical press as there is no different results in term of yield and characteristic of crude palm oil produced. Nevertheless, the yield of oil palm loose fruits (LF) of 12 days by pressure steaming process (autoclaving) was higher about 4% than by steaming due to effect of pressure inside autoclave during steaming process. The effect of the pressure inside the autoclave also resulted in the higher of the water content of crude palm oil. The composition of the mesocarp (flesh of fruit) of oil palm loose fruits (LF) was about 55% and the seeds was around 45%. The palmitic acid increased with the increasing the processing delay of the oil palm loose fruits (LF). Palmitic acid is a type of saturated fatty acid composed of 16 carbon atoms and has similarities with hydrocarbon compounds found in petroleum, so it can be confirmed that oil palm loose fruits (LF) have potential as a source of biofuel. Hence, it can be concluded that oil palm loose fruits (LF) that have passed the processing delay of up to 12 days still have the potential to provide added economic value. Mesocarp could be extracted to produce crude palm oil (CPO) while the seeds can be extracted to produce crude palm kernel oil (CPKO), both of them are raw material for food and energy industries.

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