The effect of contact time of adsorbent made from palm oil mill boiler ash on crude palm oil quality

S Mayyoga*, I U P Rangkuti and H Purwanto

Department of Plantation Product Processing Technology, Sekolah Tinggi Ilmu Pertanian Agrobisnis Perkebunan, Medan, Indonesia.

E-mail: *sandimayyoga1@gmail.com

Abstract. Indonesia as an agricultural country, produces agricultural products and their waste. To increase the utilization of agricultural waste, hence Palm Oil Mill Boiler Ash processed into an adsorbent. This research aimed to determine the effect of contact time on the quality adsorption process of crude palm oil using adsorbent from Palm Oil Mill Boiler Ash. The results showed that the optimum contact time at 60 minutes resulted in the largest reduction in free fatty acids by 2.99% with a decrease in the percentage of 21.43%. The minimum water content of crude palm oil was 0.26% with a decrease in the percentage of 18.75%. Meanwhile, the impurities obtained in crude palm oil are around 0.299% - 0.312%. This showed that the boiler ash adsorbent, originating from the Palm Oil Mill, which activated with H₃PO₄ is effective in reducing free fatty acids and water content in crude palm oil.

1. Introduction

Crude palm oil is one of the mainstays of Indonesian plantation products, used as raw material for cooking oil, which contains α- and β-carotene, tocopherols, and tocotrienols [1]. Palm oil processing requires quality, both qualitatively and quantitatively. The quality of palm oil production as a food ingredient has quality aspects related to fatty acid content, water content, and impurity content [2].

Several studies have been conducted regarding the adsorption of free fatty acids using adsorbents, [3] have adsorbed FFA from CPO using palm oil empty fruit bunches ashes. It was reported that the lowest percentage of decrease occurred at 60th minutes with an initial FFA level of 7.33%, dropping to 4.739%. The ash adsorbent of palm oil empty fruit bunches works well because it can reduce the water and the impurity contents even though the difference is not that significant.

This research used the boiler ash of palm oil mill as adsorbent. The boiler ash content consists of SiO₂ 31.45%, CaO 15.2%, and Al₂O₃ as much as 1.6% [4]. The use of adsorbents is an effective alternative method because it uses the by-product of processed palm oil that is boiler ash. This research used the content of boiler ash to reduce high FFA content. Furthermore, boiler ash was activated using H₃PO₄ which was applied to adsorb FFA in CPO through batch methods and several other CPO quality tests such as water and impurities content test.
2. Data and methods

2.1. Sample preparations
The raw materials in the form of crude palm oil and boiler ash as adsorbents were obtained from the PTPN II, Pagar Merbau Palm Oil Mill.

2.2. Boiler ash activation
First, the boiler ash was filtered using a 200-mesh sieve. Furthermore, the boiler ash was immersed in 10% H3PO4 solution for 24 hours then, washed it with distilled water to neutralize the pH. Last, dried it using an oven at 110°C for 2 hours [5].

2.3. CPO characteristics

2.3.1. Free fatty acid. A total of ± 5.0 grams of sample at 60°C temperature was dissolved in 50 mL of 95% ethanol. Furthermore, the sample was conditioned at a temperature of 40°C. Add 3 drops of phenolphthelin indicator to Erlenmeyer, then titrated it with 0.1 N NaOH solution until the colour change (brick red) [6]. Free fatty acid content was calculated based on the equation:

\[
\text{Free fatty acid (\%)} = \frac{25.6 \times N \times V}{W}
\]  

(1)

2.3.2. Water content. A total of ± 10 g of CPO was put into an empty porcelain crucible (W₀) then the porcelain crucible containing CPO (W₁) was heated in an oven at 130°C for 30 minutes after that, it was cooled in a desiccator for 15 minutes and the crucible was weighed (W₂). The analysis was carried out in 3 repetitions [6]. The percentage of water content in CPO used the following formula:

\[
\text{Water Content (\%)} = \frac{W₁ - W₂}{W₁ - W₀} \times 100\%
\]  

(2)

A certain amount of sample (by weight) was dried in an oven at 103°C for 30 minutes, then cooled in a desiccator for 15 minutes. Enter 50 mL of n-hexane solvent into the sample bottle, shaking it until all the oil dissolves, then filtered it with paper. Washing was done several times using solvent, each time as much as 10 ml until the filter is clean of oil. The filter media with all of its contents was dried in an oven at 103°C for 30 minutes, then cooled in a desiccator for 15 minutes, and weighed [6]. The impurity content was calculated by the equation:

\[
\text{Impurity Content (\%)} = \frac{W₁ - W₂}{W₁ - W₀} \times 100\%
\]  

(3)

2.4. Determination of contact time of palm oil mill boiler ash adsorbent
The application process of boiler ash for adsorption begins by weighing 0.1 gram of activated boiler ash using an analytical balance, then mixed with it 50 ml of crude palm oil (CPO). Furthermore, observations were made at the adsorbent contact time for 30 minutes, 60 minutes, and 90 minutes with heating at 55oC. The analysis was carried out 3 times [5].

3. Results and discussion
In this research, the adsorbent was applied to the crude palm oil to determine the optimum contact time to identify the duration of adsorbent to adsorb free fatty acids, the water content, and also its effects on CPO impurity content. The results obtained from determining the contact time for free fatty acids are presented in Figure 1.
In Figure 1, it can be seen that the best reduction occurred at 60 minutes of contact time, in which the free fatty acid content was 2.99%. This indicated that the longer the contact time, the more boiler ash adsorbents will interact and produce the Van der Walls force in the form of tensile force between the free fatty acid particles and the adsorbent, causing free fatty acids to stick to the adsorbent [3].

The increase in the percentage of free fatty acids adsorbed by the boiler ash adsorbent occurred at 90 minutes. The free fatty acid content obtained was greater than before, which is 3.28%. Free fatty acid content at 90 minutes of contact time increased. In this situation, the adsorption ability of boiler ash adsorbent has decreased because the longer the oil interacts with the heat it will trigger the formation of free fatty acids [7]. The optimal optimum time in this study is 60 minutes.

The application of adsorbents to crude palm oil not only affects free fatty acids but also on the water content of crude palm oil, as presented in Figure 2.

The water content of crude palm oil before and after adsorption did not change significantly, but the effectiveness of the adsorbent of boiler ash from the Palm Oil Mill worked well because it can reduce the water content even though the difference is not that significant (Figure 2). The best reduction in water content occurred at 60 minutes of contact time, in which the water content was 0.26%. In this minute, it also obtained the largest percentage of absorption of water content by the oil palm boiler ash adsorbent, which was 18.75%. According to Bahri (2014) [8], the water is lost due to the heating process. The water adsorption process by the adsorbent cannot be said to have a significant effect because the hydrogen bonds that occur are weaker than other macromolecular forces on the active-side of the adsorbent surface.
The increase in the percentage of water content adsorbed by the Palm Oil Mill boiler ash adsorbent occurred at 90 minutes. The water content obtained was greater than before, that is 0.29%. The increase in water content at the contact time of 90 minutes is closely related to the hygroscopic properties of the activator used, which is H₃PO₄. The greater the H₃PO₄ concentration, then the lower the water content of crude palm oil. Activator binding of water molecules in crude palm oil causes the adsorbent pores to get larger. The larger the pores, the more the adsorbent surface area increases. This increase in the surface area resulted in the greater ability to push water molecules below the oil surface to the top and accelerate the evaporation process, which means that the water content of crude palm oil is getting better [9].

Table 1. CPO characteristics test results

| Contact Time | Free Fatty Acids | Std. Deviation | Water Content | Std. Deviation | Impurity Content | Std. Deviation |
|--------------|------------------|----------------|---------------|----------------|------------------|----------------|
| 0 minute     | 3.80             | 0.32           | 0.069         |                |                  |                |
| 30 minutes   | 3.37             | 0.12           | 0.29          | 0.01           | 0.299            | 0.0131         |
| 60 minutes   | 2.99             | 0.12           | 0.26          | 0.17           | 0.312            | 0.0215         |
| 90 minutes   | 3.28             | 0.06           | 0.29          | 0.005          | 0.305            | 0.0136         |
| SNI 01-2901-2006 | 5%                  | 0.5%          | 0.5%          |                |                  |                |

Before and after adsorption, the impurity content of CPO increased along with the application of Palm Oil Mill boiler ash adsorbent. There is no absorption of impurities in the crude palm oil by the Palm Oil Mill boiler ash adsorbent. In general, samples impurities were obtained from the processing in the Palm Oil Mill. The high levels of impurities in crude palm oil after adsorption is due to the filtrate is not filtered with the aid of a vacuum pump. Besides, sampling for analysis of impurity content is not filtered first using Whatman filter paper no. 41 [10]. Therefore, the addition of boiler ash adsorbent from Palm Oil Mill naturally or from the crude palm oil production process remains in crude palm oil. These components/compounds cause high levels of impurities in crude palm oil.

4. Conclusions
The optimum contact time for adsorption of free fatty acids in crude palm oil occurred at 60 minutes, with the number obtained was 2.99%, and the percentage of reduction was 21.43%. The decrease in water content in crude palm oil occurred in the 60th minute, with the obtained number of 0.26% and the percentage reduction of 18.75%. There is no absorption of impurities in crude palm oil by the Palm Oil Mill boiler ash adsorbent, and the impurities in crude palm oil are around 0.299% - 0.312% because the adsorbent used produces residue.

References
[1] Rifin A 2017 Jurnal Manajemen & Agribisnis 4
[2] Liang T 2009 Seluk Beluk Kelapa Sawit [Ins and Outs of Palm Oil] Sawit Kalbar
[3] Syahwandi M, Winda R, Titin A and Thamrin U 2019 J. Pure App. Chem 2 3 pp 121-9
[4] Prianti E, Malino B, and Lapanporo B 2015 Positron 1 pp 26-9
[5] Triawan, Deni A, Nesbah and Dyah F 2017 Jurnal Kimia Riset pp 10-5
[6] Badan Standarisasi Nasional Indonesia [Indonesian National Standardization Agency] 2006 Minyak Kelapa Swit Mentah (Crude Palm Oil) SNI 01-2901-2006 (Jakarta: Departemen Perdagangan [Department of Trade])
[7] Siti, J, Intan D and Elza N 2014 ST Thesis (Yogyakarta: Ahmad Dahlan University)
[8] Bahri S 2014 Jurnal Dinamika Penelitian Industri 25 1 pp 63-9
[9] Fajiatri K 2016 SSi Thesis (Yogyakarta: Islam Negeri Sunan Kalijaga University)
[10] Ummul H, Ika K, Husnul M and Mutiah H 2019 Jurnal Konversi 8 1