Crude Palm Oil Processing and Quality Control (FFA) Testing to Control CPO Oil Quality at PT. Berkat Sawit Sukamaju

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ABSTRAK

Tujuan penelitian ini yaitu untuk mengetahui analisis quality control mutu Free Fatty Acid minyak CPO di PT. BSS Sukamaju. Metode yang digunakan dalam menganalisa FFA dari Crude Palm Oil ini adalah metode titrasi volumetri yaitu dengan menggunakan larutan standar 0,1046 sebagai pentiter, Phenolpthalein sebagai indikator dan campuran isopropilalkohol sebagai pelarutnya yang dilakukan pengamatan selama 5 hari. Hasil rata-rata FFA yang di dapatkan pada tanggal 25 september 2021 sampai dengan 29 september 2021 adalah 3,8% dengan standar max 5%, dan pada hasil pengamatan moisture didapatkan rata-rata 0,13% dengan standar max 0,20%. Sedangkan hasil pengamatan dirt dengan rata-rata sebesar 0,0178% dengan standar max 0,02%. Dengan demikian sebagai ukuran standar mutu dalam perdagangan internasional untuk FFA ditetapkan sebesar 5% yang artinya dalam PT.BSS telah memenuhi standar mutu dalam perdagangan internasional. Pengendalian quality control yang dilakukan sangat berpengaruh dalam kualitas produk sehingga dapat mempengaruhi dalam pendapatan karena nilai jual dalam pemasaran sangat bergantung pada mutu atau kualitas dari CPO tersebut.

Keywords:
Crude Palm Oil
Free Fatty Acid
Quality Test

ABSTRACT

Crude Palm Oil Processing and Quality Control (FFA) Testing to Control CPO Oil quality at PT. Berkat Sawit Sukamaju. This study aimed to determine the quality control of Free Fatty Acid CPO oil at PT. BSS Sukamaju. The method used in analyzing the FFA of Crude Palm Oil is the volumetric titration method using 0.1046 standard solutions as the titer, Phenolphthalein as an indicator, and a mixture of isopropyl alcohol as the solvent, which was observed for 5 days. The average FFA results obtained from September 25, 2021, to September 29, 2021, are 3.8% with a max standard of 5%, and the humidity observation results get an average of 0.13% with a max standard of 0.20%. The results of the observation of dirt with an average of 0.0178% with a max standard of 0.02%. Thus, as a measure of quality standards in international trade, FFA is set at 5%, which means that PT. BSS has met quality standards in international trade. Quality control that is carried out is very influential in product quality, so it can affect revenue because the selling value in marketing is very dependent on the quality of the CPO.

INTRODUCTION

Indonesia's Crude Palm Oil (CPO) industry plays a key role in the national economy, with growing export prospects due to rising global demand and limited supply. Factors such as production efficiency, quality improvements, and market dynamics influence the competitiveness of Indonesia's CPO in international markets, impacting export volumes and its global market position (Betrix et al., 2022). The industry faces challenges like export tariffs and negative campaigns but has opportunities, especially in expanding market share in countries like India, where Indonesia has a competitive advantage (Sulaiman et al., 2024). CPO's role in biodiesel production also presents an opportunity, though it must be managed alongside food security concerns (Mayasari & Dalimi, 2017). The economic significance of CPO as a foreign exchange earner highlights the importance of stabilizing export volumes (Gultom & Sinaga, 2023), with domestic factors like production and prices affecting exports more than international prices (Anzani et al., 2023). Strategic management and policy measures are essential to balance export growth with domestic needs and respond to external factors like geopolitical tensions and global economic conditions.

CPO (Crude Palm Oil) is extracted from oil palm fruit, and various physicochemical factors and processing and storage conditions influence its quality. Key quality indicators include free fatty acid (FFA) content, moisture, and impurities, where high FFA levels can lead to undesirable taste and odor, with a standard limit of 5% (Edyson et al., 2022). Factors such as fruit maturity, pest attacks, and poor harvesting, transportation, and storage practices can increase FFA levels and reduce CPO quality (Dongho et al., 2016; Sari et al., 2021). The use of efficient processing equipment and quality control methods, such as Six Sigma and titration, is crucial to maintaining CPO quality (Azmi et al., 2024; Prananda & Furqan, 2024). Additionally, challenges in international trade due to contaminants like 3-MCPD and glycidyl esters also affect CPO quality standards (Syafrianti et al., 2021).

PT. Berkah Sawit Sukamaju (PT. BSS) is a palm oil processing company that produces CPO, an essential raw material in the global food processing industry. The quality of CPO is primarily determined by key parameters such as FFA and water content, which influence its stability, shelf life, and suitability for further processing. Maintaining low FFA and moisture levels is crucial to meet industry standards and consumer expectations (Nurulain et al., 2021; Wirawan et al., 2022). High FFA levels, often caused by fruit bruising and poor storage conditions, negatively affect oil quality, while excessive moisture promotes hydrolysis and microbial growth, further degrading CPO quality (Azmi et al., 2024; Emebu et al., 2022). Analytical methods like titration and gravimetric analysis are used to measure these parameters, ensuring that the oil meets quality specifications (Azmi et al., 2024). Proper storage, process optimisation, and controlling environmental factors are vital to maintaining CPO quality and addressing challenges related to sustainability and environmental impact (Syafira et al., 2022).

Increased levels of FFA in CPO significantly reduce its quality, causing issues like rancidity, off-flavours, and altered colour, which in turn decrease its market value. The primary causes of increased FFA levels are morphological damage to the oil palm fruit, such as bruising during harvesting and transportation, and microbial activity on the fruit's surface. These factors lead to the release of lipase enzymes, which catalyse the hydrolysis of triglycerides into FFAs (Tan et al., 2023). Microorganisms further accelerate this process, emphasising the need for proper handling and sterilisation (Yuandry & Irdawati, 2024). High FFA levels degrade CPO quality and pose economic challenges, reducing commercial value and consumer acceptance (Igile et al., 2023). To mitigate this, improvements in processing techniques, such as minimizing bruising and using adsorbents like activated carbon, can reduce FFA content, along with advanced technologies like membrane filtration and enzymatic remediation (Pasaribu et al., 2022; Widiastuti et al., 2022).

Ensuring product quality control, especially for CPO, is crucial to meet established standards and satisfy consumer expectations. High-quality CPO, characterized by low FFA levels, minimal impurities, and appropriate moisture content, is preferred by both refiners and consumers, and can command better market prices. As environmental and health concerns grow, producing high-quality CPO that meets sustainability standards, like the Indonesian Sustainable Palm Oil (ISPO), is vital for maintaining a positive industry image and access to global markets. Effective quality control methods, including Statistical Quality Control (SQC), DMAIC, and FMEA, are used to monitor production and improve quality. However, challenges such as human errors, machine inefficiencies, and raw material quality require continuous attention. Integrating quality control with sustainable practices can help the palm oil industry maintain its competitiveness and meet both market and regulatory expectations (Dewi & Yannimar, 2023; NG & NG, 2020; Siregar et al., 2020).

CPO quality standards are important to determine the quality of CPO oil. Therefore, this study aims to determine whether the quality control analysis of FFA quality of CPO oil at PT. BSS Sukamaju has been in accordance with the established quality standards.

METHOD

This research was conducted on September 25, 2021 to September 29, 2021, at PT. Berkah Sawit Sukamaju Sungai Lilin, Palembang City, South Sumatra Province, Indonesia. Data on FFA quality, moisture, dirt Crude Palm Oil PT. BSS was obtained by direct observation in the laboratory where the test took place with the Standard Method AOCS (American Oil Chemist Society) Ca 5a-40 and observation of CPO processing techniques. Observations were carried out for five days for each quality test.

The CPO quality analysis conducted includes FFA, moisture and dirt. The analysis procedure conducted is in accordance with SNI 01-2901-2006. CPO is heated first to a temperature of 55-60°C to make it homogeneous. Weigh 5 grams of CPO with an Erlenmeyer flask, add 50 ml of 98% IPA (Isopropyl alcohol) and 3 drops of phenolphthalein then homogenize. Titrate with NaOH until the color becomes brick red (NaOH normality: 0.1046). The free fatty acid content is calculated using equation (1).

$$\%\mathrm{FFA} = \frac{\mathrm{V.Titrationx\ N\ NaOH\ x\ BM}}{\mathrm{wieght\ of\ sample}} \tag{1}$$

Weigh 10 grams of CPO and then heat it to make it homogeneous in terms of moisture. Analyze it for 10 minutes at a temperature of 110°C, after 10 minutes the humidity of the analyzer will automatically turn off and display the results of the water content in the CPO. The empty container (crystalizing glass) is weighed using an analytical scale. The wet sample (Crude Palm Oil) is inserted, after the sample weight is obtained. The sample is heated using a hotplate until it evaporates at a temperature of 70-105°C. Then let it cool and weigh it again. The moisture content is calculated based on equation (2).

$$Moisture = \frac{\mathrm{moist\ sample} - \mathrm{dry\ sample}}{\mathrm{moist\ sample}}\, x\ 100\% \tag{2}$$

Weigh a 20 gram CPO sample and heat it on a hotplate at a temperature of 100-105°C, and cool it. Weigh the crucible which has been given filter paper. After that, the crucible and filter paper are inserted into the vacuum pump. Flush with the CPO Dirt sample, and turn on the vacuum pump. Then flush with N-hexane until clean. After cleaning, wipe the outside of the crucible. Put it in the oven for 10 minutes. After that, weigh it again. The dirt content is calculated based on the equation (3).

$$\mathrm{Dirt} = \frac{\mathrm{weight\ of\ dirt} - \mathrm{weight\ of\ container}}{sample\ weight}\, x\ 100\% \tag{3}$$

RESULTS AND DISCUSSION

The CPO processing process begins with the palm oil being transported into a sterilizer tank for boiling using an escalator then the palm oil is boiled or cooked with a steam pressure of 3 bar, a time of 75 minutes and a boiling capacity per tank of 32-33 tons. After going through the boiling process, the palm oil is separated between the loose fruit from the empty bunches or separating the fruit from the bunches. After the fruit is separated it is taken to the press station. At the station, it undergoes 2 processes namely the digester stirring or crushing to separate the nud from the fiber, while the runpres station functions to press the fiber to release oil with a pressure of 5-7 BAR and a capacity of 15 tons (pressing palm oil with shells). After completing the process, the oil produced from the squeezing is taken to the clarification station (oil purification) CST (Continue Setting Tank). At the CST, the oil will be separated from dirt temporarily by sedimentation using a mixer or agitator which functions to separate oil, emulsion, water, sutge with a temperature of 95˚C and 3 rpm rotation.

The sedimentation takes 3-4 hours. After settling, the oil that has been separated from the dirt will be taken through the shimmer oil and will be taken to the oil tank (Oil Production) (oil purification or clarification) in this tank CPO oil still contains a lot of water to separate water from oil in a vacuum dryer which functions to separate the water content of CPO with a temperature of 80˚-90˚C. After separating from the water, the oil will be taken to the storage tank before reaching the storage tank, the oil will be pumped (using purifier) which functions to filter dirt and water content and then transferred to the storage tank which functions to accommodate oil that is ready for export. The weight of this storage tank is 500, 700, and 2000 tons (PT. BSS, 2021).

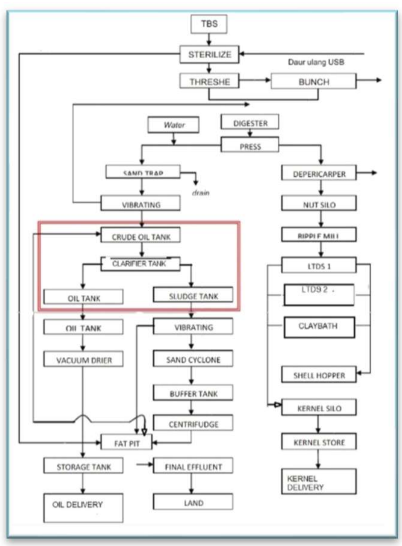

Figure 1. Flow diagram of the CPO processing process

A standard is a specification or document that is available to the public, created by general agreement of both interested parties, which will have an effect based on the consolidation of the results of knowledge, technology and experience aimed at improving safety for the community and approved by a recognized body at the regional, national and international levels (Hurst, 2006). CPO oil control can be based on quality standardisation that uses the Indonesian National Standard (SNI). SNI standards are standards used to form the basis for determining the quality of a product commonly used in Indonesia. Company quality standards are used to determine the quality of CPO oil to be distributed domestically. The quality standards used by PT. Berkah Sawit Sukamaju can be seen in Table 1.

Table 1. CPO Quality Standards at PT. BSS

Parameter	Standard	Company Quality
	SNI 01-2901-2006	
FFA	5%	5%
Moisture	0.25%	0.20%
Dirt	0.25%	0.02%

(Source: PT. BSS, 2021)

The quality standard of PT. BSS CPO oil is obtained from the results of laboratory test analysis by testing samples from the storage tank or the CPO storage tank every 2 hours. Each of the test analyses is important because from the test, it can be seen what the quality standard of the CPO produced is. The various test functions carried out include:

1. *Free Fatty Acid* Analysis

Free *Fatty Acid* (FFA) testing determines CPO oil's free fatty acid content. An increase in FFA values indicates that the oil is damaged due to hydrolysis. The higher the FFA value in oil, the worse the oil quality and vice versa; the lower the FFA value in oil, the better the oil quality.

According to Ketaren (1986) the measure for measuring the amount of free fatty acids contained in oil or fat is the acid number. The acid number is the number of milligrams of base (KOH/NaOH) needed to neutralize free fatty acids from one gram of oil or fat. In line with previous research thinking, it also states that FFA testing can be done by the alkalimetric titration method (Silalahi et al., 2017). The alkalimetric titration method is an analysis method based on acid-base reactions. The use of the Phenolphtalein (PP) indicator is because it has a pH range that tends to be basic and colorless. Color changes are easy to observe because it uses the PP indicator, while using NaOH for titration because of the nature of NaOH which is a strong base.

Figure 2 shows the diagram of the FFA levels of CPO oil at PT. Berkah Sawit Sukamaju which was carried out from September 25, 2021 to September 29, 2021.

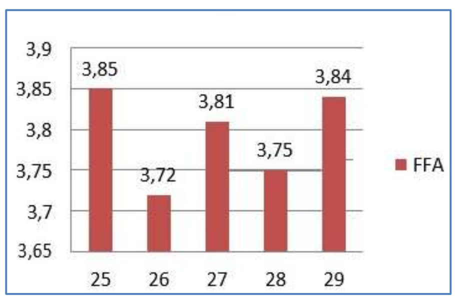

Figure 2. FFA Test Result Diagram of PT. BSS

Based on Figure 2, it can be seen that the FFA levels from September 25, 2021 to September 29, 2021 showed a value in the range of 3.72-3.85% with an average of 3.8% where the results show a value below the maximum limit determined by the company, which is 5%. Therefore, it can be seen that the CPO oil produced by PT. BSS has met SNI standards, where the FFA content of CPO in SNI is a maximum of 5%. In addition, the results of laboratory tests on the CPO produced are of very good quality because the FFA value is very low.

High levels of FFA (*Free Fatty Acid*) can be caused by increased lipase enzyme activity in CPO. Increased lipase enzyme activity is caused by several factors, such as delays in processing oil palm fruit, manual palm oil processing processes, fruit contamination by microorganisms, and physical damage to the fruit (Ali et al., 2014).

According to Yulianto (2020) the actions that must be taken to reduce the high levels of free fatty acids in CPO are: 1) Raw material factors, timely harvesting of oil palm fruit, collection and transportation of fruit as quickly as possible, fruit should not pile up for too long and fruit handling minimizes fruit damage; 2) Method factors, drying in a vacuum vessel with a temperature of around 90°C to maintain low water content in the process and production equipment and the application of CPO processing technology from waste installations; and 3) Human factors, to improve worker expertise and accuracy.

2. Humidity Analysis

Moisture testing on CPO oil is used to determine the water content in CPO. The water in CPO oil can accelerate the process of oil damage because it can cause hydrolysis, so it can affect the quality of the CPO. The lower the water content, the better the resistance of CPO oil and the quality of the oil.

According to Dewi et al. (2015) the CPO hydrolysis reaction is a reaction of CPO conversion into fatty acids and glycerol in the presence of water and lipase enzymes. One triglyceride molecule (oil or fat) will react with 3 water molecules, producing 3 molecules of fatty acids and 1 molecule of glycerol. The higher the water content in food, the higher the level of ALB formed because the hydrolysis reaction takes place faster (Pahan, 2015).

The moisture content of CPO oil at PT. Berkah Sawit Sukamaju which was carried out from September 25, 2021 to September 29, 2021 can be seen in Figure 3.

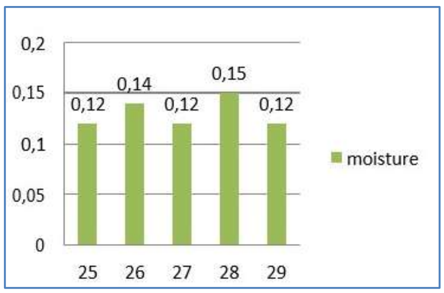

Figure 3. Diagram of PT. BSS Humidity Test Results

Based on Figure 3 it can be seen that the moisture content from September 25, 2021 to September 29, 2021 showed a value in the range of 0.12-0.15% with an average of 0.13% where the results show a value below the maximum limit determined by the company, which is 0.20% so it can be seen that the CPO oil produced by PT. BSS has met SNI standards, where the moisture content of CPO in SNI is a maximum of 0.25%, the results of laboratory tests on the CPO produced are of very good quality because the moisture value is very low.

Humidity levels that are outside normal standards can be caused by several factors such as: 1) Human factors, fatigue experienced by employees due to working hours that are too long will certainly cause decreasing the concentration; 2) Work method factors, imperfect boiling results in high water content in palm oil. Therefore, the quality improvement actions that need to be taken to overcome humidity levels outside normal limits are: 1) Method factors, less than optimal boiling can be overcome by using machines that are *set* automatically according to the needs of PT. BSS; and 2) Human factors, lack of accuracy from workers in operating work tools which causes high humidity levels.

3. *Dirt* Analysis

Dirt analysis testing on CPO oil is used to determine the level of dirt contained in CPO oil. Similar to humidity, the lower the dirt content, the better the quality of CPO oil. The dirt content is the totality of foreign materials that are not soluble in oil, which can be filtered after the oil is dissolved in a solvent (Ali et al., 2014). In general, in palm oil processing plants, CPO filtering is carried out in a series of sedimentation and centrifugation processes. In this process, large dirt can be filtered, but small dirt or fibers cannot be filtered, they only float in the CPO. The level of dirt that may be included in CPO, according to SNI 01-2901-2006, is 0.25% (BSN, 2006).

The impurities contained in CPO oil are impurities that cannot be dissolved in N-hexane or petroleum ether. The level of impurities or *dirt* in CPO oil also affects its quality. The following is a diagram of the *dirt content of* CPO oil at PT. Berkah Sawit Sukamaju, which was carried out from September 25, 2021, to September 29, 2021, is shown in Figure 4.

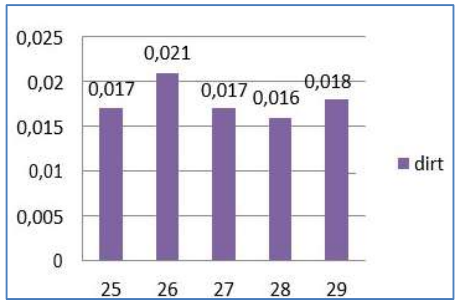

Figure 4. PT. BSS *Dirt Test Result Diagram*

Based on Figure 4, it can be seen that the dirt content from September 25, 2021, to September 29, 2021 showed a value in the range of 0.016-0.021% with an average of 0.0178%, where the results show a value below the maximum limit determined by the company, which is 0.02%. So, it can be seen that the CPO oil that is produced by PT. BSS has met SNI standards, where the moisture content of CPO in SNI is a maximum of 0.25%. The results of laboratory tests on the CPO produced are of very good quality because the dirt value is very low.

According to Yulianto (2020), the level of dirt that is outside the normal standard can be caused by several factors: 1) Human factors, lack of accuracy from workers and fruit receiving stations in dealing with the large amount of waste that is included, which causes the level of dirt to increase; 2) Work method factors, such as poor machine performance, cause a large amount of dirt to be included in processing; and 3) Raw material factors, the amount of waste that is included during collection, so that it is included in processing, both inorganic and organic forms.

So, quality improvement actions need to be taken to address the humidity levels. Outside the normal limits are: 1) Human factors, must always be supervised by assistants or foremen so that the incidence of waste entry in processing can be prevented, and also training is provided to fruit sorting employees to be better at PT. BSS; 2) Work method factors, improving the quality of the refining machine so that it can work well and the level of dirt in CPO at PT. BSS can be good; and 3) Raw material factors, separation of inorganic and organic waste during collection, both during the transportation of TBS fruit.

CONCLUSION

Based on the analysis conducted from September 25 to September 29, 2021, it was found that the levels of free fatty acids (FFA). The moisture content and *dirt content* of *Crude Palm Oil* (CPO) met the quality standards set by PT. Berkah Sawit Sukamaju also met the quality standards set by SNI 01-2901-2006.

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