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*Research Article*

# Determination of Content and Oil Losses in Meal through Palm Kernel Pressing Process at PT XYZ Belawan

*Penentuan Kadar dan Kehilangan Minyak pada Meal dalam Proses Pressing Palm Kernel di PT XYZ Belawan*

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## Abstract

PT XYZ Belawan has a kernel crushing plant unit that produces Crude Palm Kernel Oil (CPKO) with 700 tons/day capacity. Palm kernel processing is carried out in two pressing stages. The first stage or first press produces oil and cake, while the second stage or second press produces oil and meal. The meal still contains 7-8% of the oil content. This study is aimed to determine the amount of CPKO yield, oil content, and oil losses in a meal during the pressing palm kernel process. The method used was the calculation of the mass balance in each process flow. The mass balance calculation is carried out after collecting the secondary data from the factory, including the analysis of water content, solids, FFA, and oil content. Based on the calculation results, CPKO yield was 48.10% of the average kernel mass rate of 714.7155 tons and met the plant standard of at least 44%. Furthermore, the average yield of oil content from the meal was 7.45% and oil losses were 3.86%.

**Keywords:** CPKO; mass balance; oil loss; palm kernel pressing

## *Abstrak*

*PT XYZ Belawan memiliki unit pabrik kernel crushing plant yang menghasilkan minyak inti kelapa sawit (Crude Palm Kernel Oil/CPKO) dengan kapasitas 700 ton/hari. Proses pengolahan inti kelapa sawit dilaksanakan dengan dua tahap pengepressan (pressing). Tahap pertama atau first press yang menghasilkan minyak dan cake sedangkan tahap kedua atau second press yang menghasilkan minyak dan meal. Meal masih mengandung kadar minyak sebanyak 7-8%. Tujuan penelitian ini adalah untuk menentukan banyaknya rendemen CPKO, kadar minyak dan kehilangan minyak pada meal selama proses pressing palm kernel. Metode yang digunakan adalah perhitungan neraca massa pada setiap aliran proses. Perhitungan neraca massa dilaksanakan setelah pengumpulan data sekunder dari pabrik, meliputi: analisis kadar air, padatan, FFA, dan kadar minyak. Berdasarkan hasil perhitungan diperoleh rendemen CPKO sebanyak 48,1105% dari rata-rata laju massa kernel 714,7155 ton dan memenuhi standar pabrik minimal 44%. Selanjutnya diperoleh hasil rata-rata kadar minyak yang dihasilkan dari meal sebanyak 7,45% dan kehilangan minyak sebanyak 3,86%.*

***Kata kunci**: CPKO; kehilangan minyak; neraca massa; pressing palm kernel*

## 1. Introduction

Palm fruit, one of the essential commodities in plantation corps, is produced by oil palm plantations [1]. This is because it can be processed and used to produce palm oil (Crude Palm Oil/CPO) and palm kernel oil (Crude Palm Kernel Oil/CPKO) products [2]. This product is a non-oil and gas foreign exchange source for Indonesia [3]. In addition to CPO, which is the dominant product for the palm oil processing industry in Indonesia [4], CPKO has also received particular attention as a product of economic value [5], which is used as a lubricant and emulsifier and is widely used in the paint manufacture materials [6],such as soaps and candles, as well as raw materials in the biodiesel manufacture [7].

Oil that is produced from palm fruit consists of two types, which are the raw material of fruit flesh (mesocarp), which is produced through a boiling and pressing process [8], and is known as crude palm oil (CPO) [9]. Also, the raw material of palm kernel which is known as palm kernel oil (PKO) [10]. A by-product of PKO is palm kernel meal or pellets. The meal is a palm kernel that has undergone a process of extraction and drying [11]. The composition of palm kernel oil is almost similar to oil that is derived from palm oil. Both of these oils can be made into various types of products. The oil processing include refinery and extraction. The results of the processing from the refinery and extraction unit is producing several kinds of oil, including oil that is ready to use and oil that must be processed again to become other products such as food products, like cocoa butter substitute, shortening, margarine, and non-food products, including fatty acid, fatty alcohol and fatty methyl ester [12].

In every treatment process, the company always prioritizes quality and optimizes the amount of CPO and CPKO yields. One of the management systems that can be applied to obtain the optimal amount of oil yield is suppressing the occurrence of oil losses during the production process [13]. Oil yield is related to oil loss, in which if the oil loss is high, the oil yield becomes lower and vice versa [14]. The amount of oil loss can be reduced by treating the residual waste dregs [15]. Generally, to reduce the oil content in the waste residue is by adjusting the pressure. Too high pressure will result in a higher number of broken seeds [16] and can damage the screw press [17]. Palm oil mills (POM) must always ensure that it works based on the appropriate standards or regulations during the process.

PT XYZ Belawan is a factory that manufactures oil from palm fruit raw materials located in Belawan, North Sumatra, Indonesia. This factory has a kernel crushing plant (KCP) unit with a production capacity of 700 tons/day, which is one of the CPKO-producing factories that produces palm kernel expeller (PKE) by-products. Palm kernel processing in the KCP unit is carried out through a weighing station, receiving palm kernels (intake station), storing palm kernels (seed silo), pressing, and storing meals (flat silo). The pressing process is divided into two processes: the first press and the second press. In the first press, the palm kernel is treated with pressure, producing oil and cake. In the second press, the cake from the first press is pressed to produce oil and meal as the output material [18].

The investigation of oil loss in CPKO processing at PT XYZ was carried out using the seven tools method, which focuses on case studies (library studies) and direct field studies. The results of the qualitative descriptive study concluded that the company suffered losses due to high oil losses for four months of 8.92% [19]. In addition to CPKO, oil loss is also occurred in CPO, which was analyzed using statistical process control methods at PT Bastian Olah Sawit Tungkal Palembang. The results of this study concluded that the loss of CPO exceeded the maximum threshold [20].

In processing palm kernel, paying attention and determining the amount of CPKO obtained in several raw materials entering the factory is necessary. Furthermore, the amount of oil loss during the processing process is also significant in determining whether to meet factory standards and avoid losses. Based on that reason, this study was conducted to calculate the CPKO yield obtained in the processing of raw materials, the oil content obtained from the meal, and the value of oil loss obtained in the pressing palm kernel process.

## 2. Research Methods

The initial data collection in this study began with secondary data from PT XYZ Belawan factory in the Palm Kernel pressing process, which included the number of processed kernels (tons) per day, the number of CPKO (tons) per day, and the number of the meal (tons) per day. Then, secondary data collection was carried out for six days of observation with the conditions and parameters of factory production following the quality standards set by the company.

### 2.1 Tools and Materials

Some of the tools used in this study include a Soxhlet extraction set, extraction flask, electro mantle, desiccator, oven, kernel grinder, NIR-InfraAlyzer 2000, rotary evaporator, spectrophotometer, and analytical balance. The materials used are the kernel, meal, n-hexane p.a, potassium hydroxide, ethanol p.a, and phenolphthalein indicators.

### 2.2 Analysis of Water Content and Solid Content

Determination of water content and solid content from the sample was done using a NIR-InfraAlyzer 2000 spectrophotometer. Samples of sorting, cake, and meal were crushed manually [21] with mortal first [22]. For CPKO samples, there was no special pre-treatment carried out, because the sample was in a liquid phase. Furthermore, the sample was put into a sample drawer inside the NIR-InfraAlyzer 2000 spectrophotometer. The instrument was turned on and operated with the SESAME program. The analysis system was chosen by adjusting the desired parameter. After that, the scan icon was clicked and waited for a few moments to get the spectrums. The water and solid content values were obtained directly through the data collection features and icon prediction.

### 2.3 Analysis of FFA Content

The acid-base titration method generally analyzed free fatty acid (FFA) [23]. However, the sample in this study was immediately analyzed with a NIR-InfraAlyzer 2000 spectrophotometer. The mashed kernel was placed in the rotating sample cup and operated on the device using the SESAME program and the FFA icon selection.

### 2.4 Analysis of Oil Content

The oil content of kernel and meal samples was determined using the solid-liquid soxhlet extraction method [24].

Samples were weighed as much as 100 grams, and then mashed with a kernel grinder. Paper thimble was made of filter paper and cotton then the extraction flask was weighed to a constant weight. 10 grams of smooth samples were weighed and put into the paper thimble. 150 ml of n-hexane solvents were added to the flask extraction. Soxhlet extraction tools are set up in such a way as electro mantle as a heater. Extraction was done for 6 hours. The extraction result was evaporated with a rotary evaporator to get oil and evaporate the solvent. Furthermore, the extraction flask is inserted into the oven at 103 $^oC$ for 1 hour. The oil-containing flask is then placed in a desiccator for 30 minutes and weighed to a constant weight. The yield/oil content is calculated using an equation (1).

$$\text{Oil Content} = \frac{\text{Extraction Oil Mass}}{\text{Sample Mass}} \text{ x } 100\% \quad \textbf{..........(1)}$$

## 2.5 Calculation of Mass Balance

The mass balance is a proper calculation of all the materials that enter, accumulate, and come out within a specific time [25]. Material equilibrium (mass balance) can be formulated in the conservative system [26] in the palm kernel pressing process, as shown in Figure 1. $F^1$ is the mass rate of the kernel that enters the first press (tons/day), $F^2$ is the CPKO mass rate that comes out of the first press (tons/day), $F^3$ is the mass rate of cake that comes out of the first press and will enter the second press (tons/day), $F^4$ is the mass rate of CPKO that comes out of second press (tons/day), and $F^5$ is the mass rate of Palm Kernel Meal (PKM) that comes out of second press (tons/day). Each process' component balance includes water, oil, FFA, and solid content. The total mass balance of both first press and the total mass balance in the second press is formulated through equation (2). By calculating the mass balance, the values of $F^2$, $F^3$, and $F^5$ can be determined as well as the value of water, oil, FFA, and solid content from the meal that comes out after going through the second press unit.

$$F^1 = F^2 + F^3 \quad \textbf{......................(2)}$$

$$F^3 = F^4 + F^5 \quad \textbf{......................(3)}$$

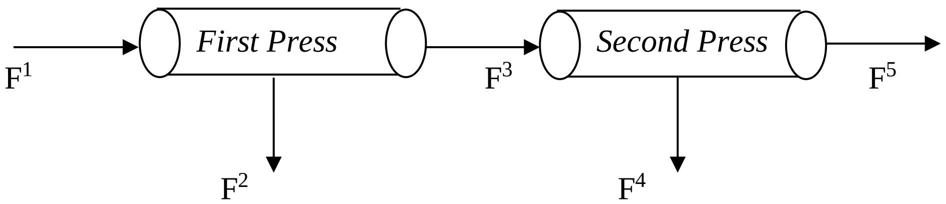


**Figure 1.** Mass balance of pressing palm kernel process

## 2.6 Determination of Oil Loss

To obtain the amount of oil loss in the meal, first determine the amount of oil using equation (4) and assigns the percentage of oil loss using equation (5).

$$A = B \text{ x } C \quad \textbf{................(4)}$$

A is the amount of oil in the meal (tons); B is the oil content (%), and C is the amount of meal production (tons). The value of B is obtained by calculating the mass balance after going through a process in the second press.

$$\%OI = A/D \text{ x } 100\% \quad \textbf{..................(5)}$$

%OI is the percentage of oil loss, and D is the number of processed kernels (tons) [27].

## 3. Result and Discussion

Secondary data that was obtained directly from the factory at the palm kernel pressing unit is essential as material in the mass balance calculation. This secondary data is daily production data observed for six consecutive days with the same conditions according to the company quality standards. Daily production data is shown in Table 1. The average number of kernels processed by PT XYZ Belawan was 714.7155 tons/day with an average CPKO production of 343.7067 tons/day, and the average meal production from the second press was 371.0088 tons/day. This data found that the average CPKO yield was 48.1105% for one production. Therefore, the CPKO yield value exceeded the minimum and met the factory standards with an average production standard of 44%.

**Table 1.** Secondary data and percentage of CPKO yield

| No | Observation Day | Processed Kernel (tons) | CPKO Production (tons) | % Yield | Number of *meal* (tons) |
|---|---|---|---|---|---|
| 1 | First | 703.5400 | 348.2755 | 49.5033 | 355.2645 |
| 2 | Second | 700.0640 | 355.1769 | 50.7349 | 344.8871 |
| 3 | Third | 704.7470 | 332.2315 | 47.1420 | 372.5155 |
| 4 | Fourth | 731.7690 | 341.8084 | 46.7099 | 389.9606 |
| 5 | Fifth | 741.7110 | 349.8802 | 47.1720 | 391.8308 |
| 6 | Sixth | 706.4620 | 334.8678 | 47.4007 | 371.5942 |
| | Average | 714,7155 | 343.7067 | 48.1105 | 371.0088 |

3.1 Determination of Water, Solid, and FFA Content

Kernel samples were analyzed using the NIR-InfraAlyzer 2000 spectrophotometer with specific settings for analyzing water, solid, and FFA content. Data on water, solid, and FFA contents in the kernel and the first press output of CPKO are shown in Table 2. Meanwhile, data on water, solid, and FFA contents in the first press output of cake and the second press output of CPKO are shown in Table 3. Data on both tables were then used as values on the component balance to calculate the oil content of meal and the percentage of oil loss.

Rantawi *et al.* research [28] shows a linear correlation between the value of water content in the kernel and the quality of the FFA content in the PKO produced. The higher the water content, the higher the FFA content in the PKO. However, the value of water content in kernel varies to the value of the FFA content in the second press output of CPKO. The reason was possible because in this study, the first and second press output of CPKO were still in crude extract and not pure PKO, in which it is causing bias in measuring the FFA content.

The value of water content in the kernel and solid content in CPKO according to Indonesian National Standard (SNI) 01-0024-1987 is a maximum of 8% and 6% [29]. Therefore, referring to the Indonesian National Standard (SNI), the water content value in the kernel and the solid content value in CPKO remained below the maximum limit. This was similar to the research results of Daulay *et al.* [30], which revealed that the quality of the kernel from the factory under study met the SNI requirements for the kernel water content, but the solid content was still above the SNI limit.

3.2 Determination of Oil Content

Oil content in the kernel, first press output of CPKO, first press output of cake, and second press output of CPKO were determined by the soxhlet method. The results of the analysis of oil content are shown in Table 4. The average oil content value in the kernel reached 50% of the total kernel. The acquisition of this value showed that the kernel used as the raw material at PT XYZ Belawan factory was satisfactory, because the oil content exceeded the minimum SNI limit of 46%.

**Table 2.** Data on water, FFA, solid contents in kernel and first press output of CPKO

| No | Observation Day | Kernel | | | First Press Output of CPKO | | |
|---|---|---|---|---|---|---|---|
| | | Water Content (%) | FFA Content (%) | Solid Content (%) | Water Content (%) | FFA Content (%) | Solid Content (%) |
| 1 | First | 7.59 | 2.55 | 38.97 | 8.85 | 2.30 | 3.00 |
| 2 | Second | 6.78 | 2.31 | 39.96 | 8.80 | 2.19 | 3.01 |
| 3 | Third | 7.67 | 2.38 | 39.62 | 8.90 | 2.25 | 3.15 |
| 4 | Fourth | 7.32 | 2.05 | 40.26 | 8.95 | 2.03 | 3.47 |
| 5 | Fifth | 7.74 | 2.03 | 39.97 | 8.98 | 2.00 | 3.60 |
| 6 | Sixth | 7.59 | 2.15 | 39.98 | 8.92 | 2.10 | 3.35 |

**Table 3.** Data on water, FFA, solid contents in first press output of cake and second press output of CPKO

| No | Observation Day | First Press Output of Cake | | | Second Press Output of CPKO | | |
|---|---|---|---|---|---|---|---|
| | | Water Content (%) | FFA Content (%) | Solid Content (%) | Water Content (%) | FFA Content (%) | Solid Content (%) |
| 1 | First | 6.58 | 1.15 | 77.57 | 12.80 | 0.47 | 2.37 |
| 2 | Second | 5.01 | 1.18 | 80.01 | 12.70 | 0.56 | 1.94 |
| 3 | Third | 6.80 | 1.12 | 77.18 | 12.85 | 0.35 | 2.25 |
| 4 | Fourth | 6.21 | 1.10 | 77.34 | 12.90 | 0.40 | 2.30 |
| 5 | Fifth | 6.90 | 1.13 | 76.22 | 14.20 | 0.33 | 2.52 |
| 6 | Sixth | 6.65 | 1.06 | 77.19 | 12.87 | 0.45 | 2.20 |

**Table 4.** Oil content data distribution

| No | Observation Day | Oil Content (%) | | | |
|---|---|---|---|---|---|
| | | Kernel | First Press Output of CPKO | First Press Output of Cake | Second Press Output of CPKO |
| 1 | First | 50.89 | 85.85 | 14.70 | 84.36 |
| 2 | Second | 50.95 | 86.00 | 13.80 | 84.80 |
| 3 | Third | 50.33 | 85.70 | 14.90 | 84.55 |
| 4 | Fourth | 50.37 | 85.55 | 15.35 | 84.40 |
| 5 | Fifth | 50.26 | 85.42 | 15.75 | 82.95 |
| 6 | Sixth | 50.28 | 85.63 | 15.10 | 84.48 |

**Table 5.** Data distribution of oil content in meal and oil loss

| No | Observation Day | Oil Content in *Meal* (%) | Oil Loss (%) |
|---|---|---|---|
| 1 | First | 7.78 | 3.92 |
| 2 | Second | 7.98 | 3.93 |
| 3 | Third | 7.37 | 3.89 |
| 4 | Fourth | 7.31 | 3.89 |
| 5 | Fifth | 7.11 | 3.75 |
| 6 | Sixth | 7.19 | 3.78 |
| | Average | 7,45 | 3.86 |

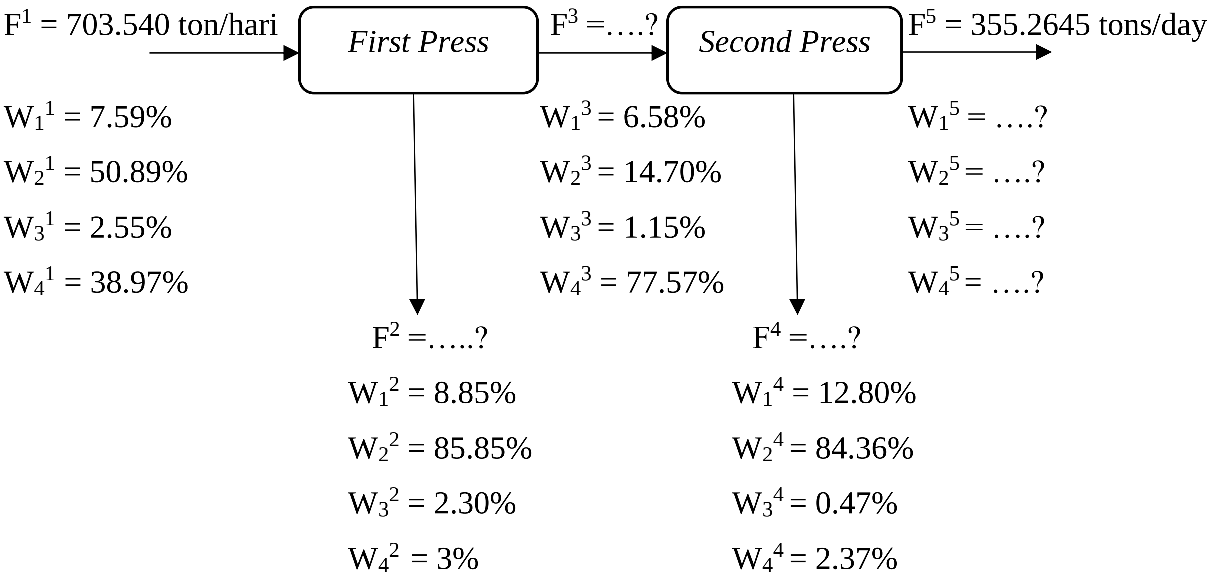


**Figure 2.** Mass balance scheme of palm kernel pressing with data distribution from the first day of observation

3.3 Determination of Oil Loss in Meal

In this study, the secondary data on the number of meal production from PT XYZ Belawan factory is shown in Table 1. Meanwhile, the amount of oil and the percentage of oil loss in the Palm Kernel pressing process is shown in Table 5. The average oil content in the meal was 7.45%, with the percentage of oil loss of 3.86%. The maximum standard value of PT XYZ Belawan factory for the percentage of oil loss was 3%, so the percentage value of oil loss has crossed the standard limit. Many factors were thought to have contributed to this case, such as minor damage to the pressing unit and the high oil levels in the Palm Kernel Expeller. However, if referred to several studies, it was found that the percentage of oil loss in the pressing unit was < 8% [19,27]. Hence, based on this standard, the percentage of oil loss remained within the normal limits.

## 4. Conclusion

Based on the results of sample analysis and calculation using the mass balance principle, it can be concluded that the average CPKO yield produced was 48.1105% of the average kernel processed 714.7155 tons/day. This value meets the minimum factory standard with a minimum percent yield of 44%. Furthermore, the value of oil content in meal and oil loss was obtained with an average of 7.45% and 3.86% respectively.

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