
Analysis of The Ripeness And Weight of Fresh Fruit Bunches (FFB) nn Oil Content And FFA

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Abstract

The quality of palm oil is greatly influenced by the quality of the processed fresh fruit bunches (FFB), especially based on the maturity level and weight of the bunches. The difference in FFB characteristics can affect the oil yield and the level of Fatty Acid (FFA) produced. This study aims to analyze the effect between the weight and maturity level of FFB on oil content and FFA content. The research method was carried out by sampling FFB in grading which was grouped based on weight (light <5 kg, medium 5–10 kg, and weight >10 kg) and fruit ripeness level (raw, ripe, and late ripe). The purpose of this study is to see the relationship between the weight of FFB on the oil content produced and FFA levels, analyze the influence of FFB maturity level on yield and FFA, analyze the proportion of FFB maturity level on FFA levels and yield in palm oil. The results of the study are expected to show the relationship between FFB weight and maturity level on oil yield and FFA levels. This research is expected to provide useful scientific information for palm oil mills in improving the efficiency of the FFB grading and processing process so as to produce palm oil with better quality.

Keywords: Fresh fruit bunches (FFB), maturity level, bunch weight, oil content, FFA

INTRODUCTION

The processing of palm oil into crude oil (CPO) undergoes several processing processes such as weighing, boiling, threshing, crushedding, pressing, and refining. Success in the palm oil production process is highly dependent on the quality of fresh fruit bunches (FFB). The quality of FFB is determined by various factors, such as the weight of the bunch, the level of ripeness of the fruit, and the physical condition of the fruit when it is received at the factory (Zein & Lestari, 2019)

Looking at the composition of fresh fruit bunches (FFB) sent to palm oil mills (PKS), then. The FFB will have various grades based on maturity level. Some references say that FFB grades can generally be classified into 3 grades, namely raw fruit (*unripe*), ripe fruit (*ripe*), and overripe fruit (*over ripe*). Because FFB has different levels of ripeness, therefore the grading process when receiving fruit must be done carefully, because the level of ripeness of fruit

affects the quality of the oil that will be produced later (Iskaria & Wardhana, 2015)

Fresh fruit bunches (FFB) can be grouped into several categories based on their weight, namely light FFB weighing less than 5 kg, medium FFB weighing 5-10 kg, and heavy FFB weighing more than 10 kg. In the weight category, it has different potential oil content. FFB with higher weights identifies a greater number of lumps and a more perfect maturity, so it has the potential to produce more oil. On the other hand, lighter FFB tends to smudge less, resulting in less oil (Imam et al., 2018)

A sterilizer is a pressurized vessel that functions to boil fruit with. Steam media as a medium. Heaters derived from steam turbine waste disposal. Steam turbines are also called boilers in which heat transfer occurs to change the liquid phase. Becomes a steam phase. Steam from the boiler is flowed. Through the overflow system to the sterilizer because *the steam* is a gaseous fluid, then to. Transporting it takes pressure. Pressure. Steam is set up. Using a faucet and monitored with a pressure monitoring device. So that the steam can reach the sterilizer for use during boiling. In boiling, a temperature of 120-145°C and a pressure of 2.8 – 3.0 kg/cm² are used using a boiling time of 90 minutes (Agustian, 2023)

MATERIALS AND METHODS

Research Time and Place

The research was conducted at the Palm Oil Mill (PKS) of PT. XYZ, which is located in Randai Village, Mauri District, Ketapang Regency, West Kalimantan Province.

Ingredients

The main ingredient used in this study is Fresh Fruit Bunches (FFB) of oil palm (*Elaeis guineensis* Jacq.) Tenera variety obtained from fruit receiving stations in palm oil mills. The chemicals used include: hexane as a solvent, sodium hydroxide (NaOH) solution, phenolphthalein indicator, and isopropyl alcohol (IPA).

Tools

In addition to weight, the physical quality of FFB such as maturity, physical condition and waiting time before the processing process can also affect the quality of the oil produced. FFB is left too long before the processing process triggers hydrolysis and oxidation reactions, which lead to increased *Free Fatty Acid* (FFA) levels. FFA is one of the main parameters in determining the quality of palm oil. High FFA levels indicate a decrease in oil quality and have the potential to reduce the selling price of the final product (Arahman et al., 2021)

In palm oil mills (PKS), variations are often found in the weight and quality of FFB that enters the mill. However, not all mills have conducted a quantitative analysis of the relationship between the weight and quality of FFB with oil and FFA content. In fact, a deeper understanding of the relationship between the weight and quality of FFB with oil content and FFA can be the basis for decision-making in the grading, sorting, and FFB receipt process at the mill (Silalahi, 2017)

Based on this background, it is necessary to conduct a study entitled "Analysis of the Quality and Weight of Fresh Fruit Bunches (FFB) on Oil and FFA Content" in order to provide more in-depth information on the influence of FFB weight and quality parameters on oil quality and FFA.

The tools used in this study include digital scales (3000–5000 g capacity, 0.01 g accuracy), 100 kg capacity scales, *hotplates* with heating flasks (50–300 °C), *Soxhlet extraction tools* made of borosilicate glass with a flask capacity of 250–500 mL, burette with a capacity of 1 L, microwave ovens (600–800 W, 220 V), and other supporting equipment such as gancu, cutter, and sample sack.

Sampling Procedure

FFB samples were taken directly during the fruit receipt and sorting process at the palm oil mill. Fruit bunches are first weighed to determine the weight category (light, medium, and heavy). Furthermore, visual observation of the ripeness

level of the fruit was carried out based on the color of the fruit, the number of loose pods, and the condition of the fruit mesocarp.

Extraction Process

Before carrying out the extraction process, the process of separating the pulp from the nut is carried out using *a cutter*. After separation, the flesh and nuts are weighed using a digital scale. After that, the flesh of the fruit was weighed as much as 10 grams on a digital scale using *a petri dish* (5 outside, 3 middle, 2 inside), the sample was dried using the oven for 16 minutes. After drying, the sample is weighed again to determine the weight after drying. After that, the extraction process is carried out using samples that have been in the oven using *Soxhlet* extraction. The extraction process is carried out by placing the sample in the *thimble soxhle*, then covered with cotton, then putting it on top of the heating flask, the heating flask is placed in the Soxhlet place. Extraction is carried out for 4 hours at a temperature of 80^{0C}. After extracting, weigh the extracted oil again, then we can get the yield from the FFB sample.

Yield Formula :

$$\text{Yields} = \frac{\text{Berat hasil yang diperoleh}}{\text{Berat awal TBS}} \times 100\%$$

This FFA (*Free Fatty Acid*) test is carried out by weighing 5 grams of extracted oil, then putting it in *a pumpkin*, mixing *50 ml of isopropyl alcohol* (IPA), stirring until mixed, then adding 4 drops of *phenolphthalein indicator*, after that add NaOH liquid slowly using the sauce burret sample and shaken until pale pink. FFA (*free fatty acid*) formula: $\frac{25,6 \times N \times V}{\text{Berat sampel (g)}}$

Research Design

RESULTS AND DISCUSSION

The Effect of Maturity Level and Weight on the Yield Produced

In testing the oil yield data, I compared the variables: Weight (light, medium, heavy) and Maturity Level (raw, ripe, late ripe).

This study uses a factorial experimental design with two factors, namely the weight of fresh fruit bunches (FFB) and the level of fruit ripeness. So that treatments such as:

Table 1. Treatment Combinations

Weight	Maturity Level		
	Raw (A)	Mature (B)	Through Maturity (C)
Lightweight (1)	A1	B1	C1
Medium (2)	A2	B2	C2
Weight (3)	A3	B3	C3

Statistical Analysis

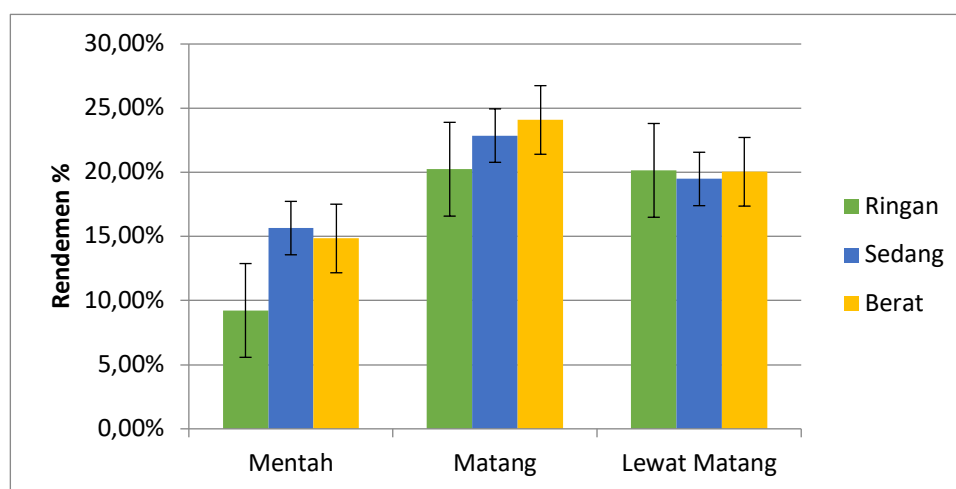
The data obtained from the observation results of oil yield and *free fatty acid content* in each treatment were recorded and compiled in the form of a table. Furthermore, the data was analyzed using descriptive statistical analysis to obtain the mean value and standard deviation of each treatment.

To find out the relationship between the weight of fresh fruit bunches (FFB) and oil yield and FFA levels, Pearson's correlation analysis was performed. In addition, the influence of FFB weight category and fruit ripeness level on oil yield and FFA levels were analyzed using variety-based analysis (bidirectional ANOVA). If there is a noticeable difference, then it is followed by a follow-up *test Duncan Multiple Range Test* (DMRT) to find out the difference between treatments.

Table 2. Data and Yield Graph generated based on maturity level vs weight

Maturity Level	Weight		
	Lightweight (1)	Medium (2)	Weight (3)
Raw (A)	9,23 %	15,65 %	14,84 %
Mature (B)	20,24 %	22,86 %	24,08 %
Late Maturity (C)	20,15 %	19,48 %	20,04 %

Based on Table 1. Next, a yield graph is made which is presented in Figure 1.

**Figure 1.** Yield Based on Maturity Level and Weight

From Figure 1, it can be seen that the most extracted oil (rendemen) with heavy conditions with a ripe maturity level, which is 24.08%, and the lowest with light conditions with a raw maturity level, which is 9.23%. According to the level of ripeness, the fruit has a great influence on the oil content (yield) produced. In general, the level of ripeness of fruit can be categorized into 3 levels, raw fruit, ripe fruit, late ripe fruit. (Syllabus & Febrianty , 2024) (Rifqi et al., 2020)

In the results of the analysis, the oil content produced increased as the FFB maturity increased.

Results of Statistical Test of Yield on FFB Maturity and Weight

Heavy and mature FFB can produce the highest oil content because at this stage the mesocarp tissue has developed physiologically to store maximum oil (Supriyanto et al., 2023) . FFB, which is still raw and light, has a low oil content because it still consists of a lot of water and carbohydrates. During the fruit ripening process, *triglycerides* physiologically accumulate in the fruit mesocarp and only reach their peak when the fruit ripens. Fruits that are still raw have not experienced maximum oil accumulation. (Hasibuan , 2020)

Table 3. ANOVA Data Two - Way Heavy

<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Maturity	134,27	2	67,136	18,115	0,0098	6,9442
Weight	17,581	2	8,7907	2,3719	0,2092	6,9442
Error	14,824	4	3,7060			
Total	166,67	8				

The results of ANOVA's analysis showed that the level of FFB maturity had a significant influence on the oil content (yield) produced and the weight of FFB did not have a significant influence on the oil content (yield) produced (Nikmalia, 2022).

The findings of the analysis show that the oil content (yield) is produced based on the weight and maturity level of a FFB. In the results of the analysis, the degree of maturity greatly affects the oil produced. In the results of the analysis, FFB with a weight of < 5 kg from the maturity level (raw, cooked, overcooked) was obtained with an average oil content of 16.54%. FFB with a weight of 5-10 kg from the maturity level (raw, cooked, overcooked) has an average oil content of 19.33%. FFB with a weight of > 10 kg from the maturity level (raw, cooked, late cooked) has an average oil content of 19.65%. (Sari et al., 2023)

Oer (*oil extraction rate*) in raw fruit was obtained with an average of 13.24%, ripe fruit with an average of 22.39%, and late ripe fruit 19.89%. Raw and ripe fruits have a difference of 9.15%, raw and ripe fruits have a difference of 6.65%, and ripe and late ripe fruits have a difference of 2.5%. According to (Squirrel et al., 2012) palm oil mills, the average oer (*oil extraction rate*) reaches 18. When compared to factory standards, the oil produced by raw fruits does not reach factory standards, in ripe fruits, the oil produced is achieved, and the fruit through ripening oil produced reaches factory standards.

According to every palm oil production activity / (Bayu & Supriyanto, 2023) *crude palm oil* (CPO), a company must maintain quality in accordance with standards. In addition, the oer (oil extraction rate) that is considered must be in accordance with the standard (20 – 24%).

Supervision of CPO quality is an obligation that must be carried out by every company. This is done to maintain the stability of CPO quality in accordance with the government, From the results of my research analysis data, ripe fruit that produces a yield that meets the company's standards, which is 24.08%. The company must strictly maintain the grading time, so that the fruit that enters to be processed is ripe fruit, so that the OER (*Oil Extraction Rate*) target can be achieved. Because in ANOVA:

- Significant Maturity Level Factor ($P = 0.00988587 < 0.05$)
- Weight Factor was not significant ($P = 0.20926937 > 0.05$)

So further tests are only carried out on the Maturity Level factor.

Table 4. Results of Advanced Tests on Maturity Levels of Oil Content

Maturity Level	Correspondence
Stuttgart	22.39 (a)
Late Maturity	19.89 (a)
Raw	13.24 (b)

Based on the results of the 5% BNT follow-up test, a BNT value of 4.36 was obtained. The results of the average comparison showed that the treatment of the ripeness and late ripeness of the fruit was not significantly different from the oil content produced, but the two were significantly different from the treatment of raw fruit. The highest average value was obtained in the treatment of ripe fruit at 22.39, while the lowest value was found in the treatment of raw fruit at 13.24.

This shows that the increase in the level of FFB maturity has an effect on increasing the yield of the oil produced. Unripe/raw fruits have not experienced maximum development in oil

formation in the mesocarp, so the oil content obtained is lower than ripe or late-ripened fruit.

Effect of Maturity and Weight on FFA Levels

Table 5. FFA data generated based on maturity vs weight level

Maturity Level	Weight		
	Lightweight (1)	Medium (2)	Weight (3)
Raw (A)	2,1 %	2,4 %	2,3 %
Mature (B)	3,2 %	3,7 %	3,5 %
Late Maturity (C)	4,3 %	5,8 %	6,4 %

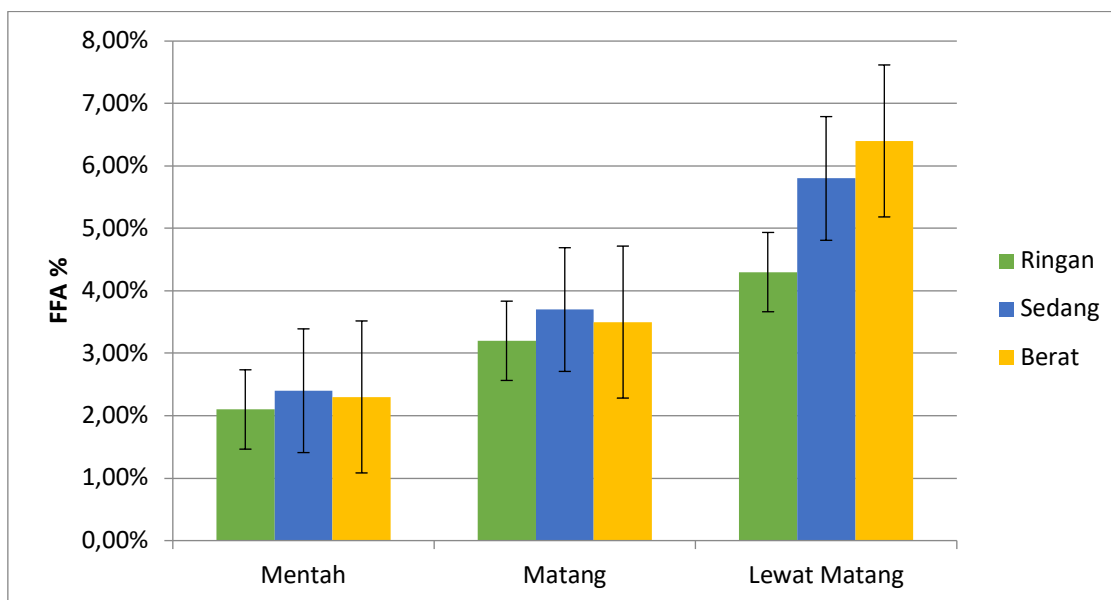


Figure 2. FFA Based on Maturity Level and Weight

From Figure 2. It can be seen that FFA is greatly influenced by the level of maturity, the highest FFA with heavy conditions and the level of late maturity which is 6.40% and the lowest FFA with light conditions and the level of raw maturity which is 2.10%.

Heavy late ripe fruit showed an FFA level of 6.40% and medium late ripe fruit showed an FFA level of 5.80%. Palm oil mills generally have FFA standards, which are below 5%. This has an impact on the decline in the quality of palm oil, because a low FFA can increase rancidity, lower DOBI, and complicate the refining process. The increase in FFA levels in late ripe fruit is caused by damage to the mesocarp network which increases the activity

of lipase and hydrolysis of triglycerides into free fatty acids (Hasibuan, 2020)

FFA (*Free Fatty Acid*) levels increase as the maturity level of a FFB increases, the more mature a FFB is, the FFA level will also rise. Mature fruits have high FFA levels because fruits experience a decrease in mesocarp cell integrity and increased (Sirait et al., 2023). *eznim lipase activity*. The enzyme breaks down *triglycerides* into free fatty acids and *glyserol*. Because overripe fruit tissue is more mushy and damaged, the *lipase enzyme* and the process of *fat hydrolysis* become more intense, so FFA levels increase (Nanda and al., 2024). Raw fruits have low FFA because the process of fat

degradation and triglyceride hydrolysis has not occurred in raw fruits. (Hasibuan , 2020)

FFA Statistical Test Results on FFB Maturity and Weight

Table 6. Data ANOVA Two - Way FFA

Source of Variation	SS	df	MS	F	P-value	F crit
Maturity	16,0288	2	8,0144	27,5305	0,0045	6,9442
Weight	1,3488	2	0,6744	2,3167	0,2146	6,9442
Error	1,1644	4	0,2911			
Total	18,5422	8				

The results of ANOVA's analysis showed that the level of FFB maturity had a significant influence on the increase in FFA levels and the FFB weight did not have a significant influence on the increase in FFA levels (Ahmadi, 2011) .

Because in ANOVA:

- Significant Maturity Level Factor ($P = 0.00458688 < 0.05$)
- Weight Factor is insignificant ($P = 0.2146532 > 0.05$)

Table 7. Results of the Advanced Test of the Maturity Level of FFA

Tingkat Maturity	Correspondence
Late Maturity	5.50 (a)
Stuttgart	3.47 (b)
Raw	2.27 (b)

The results of the 5% BNT follow-up test showed that the maturity level made a real difference to the FFA level produced. The treatment of ripe fruit is significantly different from raw fruit and ripe fruit. However, between raw fruit and ripe fruit does not show any noticeable difference.

The highest average FFA value was obtained in ripe fruit at 5.50%, while the lowest value was found in raw fruit at 2.27%. This shows that the increase in FFB maturity has an effect on increasing FFA levels. The increase in FFA is caused by the process of hydrolysis of triglycerides by the enzyme lipase which is increasingly active in fruits with advanced ripeness.

The proportion of the influence of FFB maturity level affects the yield level in palm oil.

Table 8. Proportion of Yield to FFB Maturity Level

No.	Raw	Stuttgart	Late Maturity
1	9,23%	20,24%	20,15%
2	15,65%	22,86%	19,48%
3	14,84%	24,08%	20,04%
Average	13,24%	22,39%	19,89%

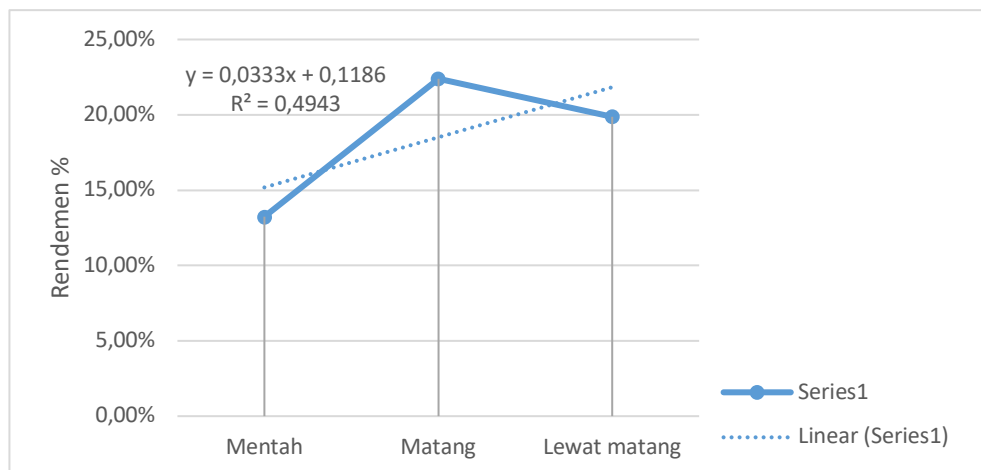


Figure 3. Proportion of Yield to FFB Maturity Level

Based on linear regression analysis, the equation $y = 0.0333x + 0.1186$ was obtained with a determination coexistence value (R^2) of 49.43%, the remaining 50.57% was influenced by other factors, such as FFB weight, boiling process, extraction process. This indicates that the lower the

maturity level, the yield tends to increase, where every increase in one maturity level increases the yield by 3.33%. However, because the value of R^2 is only 49.43, there are still other factors outside of the maturity variable that affect oil yield.

The Proportion of FFB Maturity Levels Affecting FFA Levels in Palm Oil

Table 9. FFA Proportion to FFB Maturity Level

No.	Raw	Stuttgart	Late Maturity
1	2,10%	3,20%	4,30%
2	2,40%	3,70%	5,80%
3	2,30%	3,50%	6,40%
Average	2,27%	3,47%	5,50%

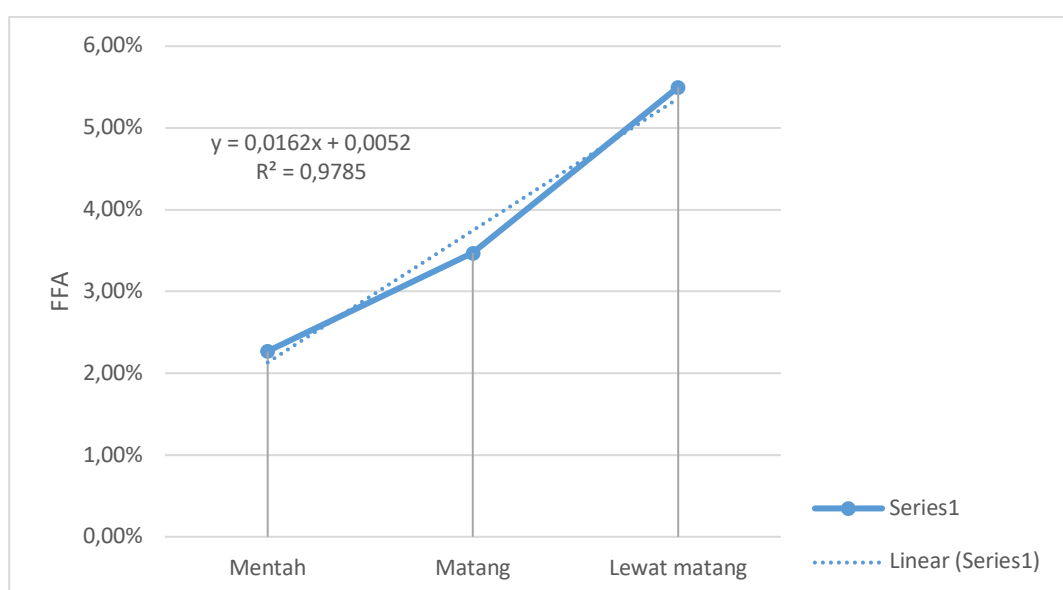


Figure 4. FFA Proportion to FFB Maturity Level

The results of linear regression analysis showed the equation $y = 0.0163x + 0.0052$ with a determination coefficient value (R^2) of 97.85%. This shows that maturity level has a very strong positive relationship with FFA. Each increase of one level of maturity increases the FFA level by 1.62%. A high R^2 value indicates that the variation in FFA levels is almost entirely influenced by the ripeness rate of the fruit.

Comparison of Yield and FFA Chart Results

CONCLUSION

Based on the results of research and data analysis, it can be concluded that: Weight on fresh fruit bunches does not affect yield and FFA. FFB

Table 10. Comparison of R^2 Yield and FFA Values

Variable	R^2	Proportion of Influence
Yields	0,4943	Medium
FFA	0,9785	Very powerful

Table 10 shows that the maturity level has a significant effect on the yield, but in FFA the maturity level has a great effect on the increase in FFA.

maturity affects yield and FFA The proportion of the influence of maturity level on yield is 49.43 5% and FFA is 97.85

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