Palm oil yield potency on different level of ripening and storage time based on fruits percentage and fresh fruit bunches

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Abstract. This study aimed at assessing the oil yield potency of palm oil, based on fruits percentage (% fruit) and percentage of fresh fruit bunches (% FFB) due to the storage at different ripeness (under-ripe, ripe, over-ripe, and loose fruit from bunches) from fresh fruit bunches (FFB) originating from plantations in Ungaran, Central Java, Indonesia. A completely randomized design (CRD) with 2 factors on the ripening and the storage levels of FFB was used. The parameters observed at the initial stage were oil contents as the basis for calculation, and the yield potencies were then analyzed on the basis of % fruit and % FFB. The data obtained were analyzed by ANOVA and continued with Duncan test α = 0.05 using SPSS version 25. Results showed that both of the ripening level of palm fruit bunches and storage time significantly (α = 0.05) affected the yield potency on the basis of % fruit or % FFB, the potential yield value was based on the percentage of fruit higher than the yield potential based on the percentage of FFB. The highest yield potential based on the percentage of fruit found on ripe FFB with a storage time of 12 hours and the lowest on under-ripe FFB with a storage time of 60 hours. While the highest potential yield based on the percentage of FFB was found on ripe FFB with a storage time of 12 hours and the lowest on under-ripe FFB with a storage time of 60 hours.

Keywords: yield, ripening, storage, FFB, palm fruit

1. Introduction
Palm fruit bunches (FFB) are the result of the cultivation of oil palm plants and are the raw materials used to produce crude palm oil (CPO). The quality of FFB can be based on the quality that is available
in it and on the basis of the quantity or amount of oil contained in the mesocarp [1,2]. In Indonesia, oil palm plants grow on the islands of Borneo, Sumatera, Sulawesi and some parts of Java [3].

Palm oil plants are said to be good if they have high production and yield. Usually, it has high quality at the production age of 3 years to 25 years. The higher the age, the higher the FFB production and yield. However, there are many factors that can affect the yield. They include seeds, plant maintenance, land suitability (height of place) and climate. Palm oil plants usually grow and develop well in areas that have a height of <400 asl, rainfall of 2000-2500 mm/year [1,4]. For the purposes of the process in the manufacture of crude palm oil (CPO), processed FFB raw materials must be in the optimum level of ripening, but it is often found that they are still fresh, too ripped and even the fruit has been separated from the bunches.

FFB that has been harvested or FFB that has been separated from its bunches due to harvesting methods, including poor transportation systems must be stored (the processing is delayed) will reduce the oil yield [5,6]. The Decree of the Minister of Agriculture of the Republic of Indonesia in 2018 said that FFB must be processed at the factory within 24 hours after being harvested from the plantations. [7]. The facts in the field indicate that the palm oil mill is targeting that the crop yield must be processed a maximum of 12 hours after harvest. While based on the standards of the Indonesian government, the maximum restoration (processing delay) is 24 hours. This is to prevent the occurrence of damage to the oil contained in the palm fruit and decreasing the yield. Oil degradation can occur due to the process of oxidation and hydrolysis in storage, poor transportation [8-10]. The longer the storage, the higher the oil degradation.

Palm oil yield is a percentage of crude palm oil (CPO) that can be obtained from a number of raw materials (FFB) while the potential oil yield is an estimate of the amount of yield from an FFB raw material. In general, to get the potential yield rate, the percentage of the amount of oil contained in the material is reduced by the loss of oil divided by FFB raw material. While the standard of oil loss in the palm oil mill is 1.775% [11-13]. But by looking at the development of science and technology, the raw material used in the processing of CPO is the palm fruit which has been fruit lose from its bunches so that there will be a difference in oil yield. And with the increasing plant age, it will increase the production and OER (oil extraction rate) [14]. After the age of 3 years on average, there is an increase of 1% in OER in farmers’ plantation in Sabah and Sarawak.

For this reason, a study was conducted to assess the level of ripening of palm fruit bunches and the length of storage against the potential yield of palm oil from FFB raw materials from the production plantation in Ungaran, Central Java, Indonesia.

2. Materials and methods

The main material of this research was palm fruit bunches (FFB) which were harvested from oil palm plants from tenera varieties (aged 12 years) of INSTIPER plantation in Ungaran, Central Java, at the ripening level of under-ripe, ripe, over-ripe and fruit loose from the bunches. Criteria for under-ripe fruit: no fruit has been loose from the bunches, ripe bunches: fruits lose from the bunches, 1-2/kg of FFB, over-ripe: fruits lose from the bunches 3-4/kg of FFB, fruits lose from the bunches (brondolan): fruits that were naturally loose from the bunches [1,11].

This study used a completely randomized design (CRD) with 2 factors. The first factor is the level of ripening of palm fruit bunches (FBF), namely: R1 = Under-ripe, R2 = ripe, R2 = over-ripe, R4 = fruit lose from bunches. The second factor is the storage time of FBF, namely: U1 = 12 hours of storage, U2 = 36 hours of storage, U3 = 60 hours of storage. Storage of FFB and the fruit lose from the bunches was by placing them in an open place. At the end of storage, an oil content analysis was conducted by taking a sample of palm fruit mesocarp then was extracted by using n-hexana with soxhlet instrument, the oil weight was divided by the sample weight and multiplied with 100 % [15], potential yield based on the percentage of fruit and potential yield based on the percentage of FFB [11, 13, 16]. The data were analysed by using ANOVA test and if there was a significant difference, the Duncan test was carried out at α = 0.05 [17].
3. Result and discussion

Based on the results of the study, it showed that the level of ripening and the storage time affect the potential yield of palm oil both based on the percentage of FFB and the percentage of the palm fruit. The results can be seen in table 1.

| Level of ripening FFB | Storage time (hour) | Potential oil yield/FFB | Potential oil yield/fruit |
|-----------------------|--------------------|------------------------|-------------------------|
|                       |                    | Mean ± SD              | Mean ± SD               |
| Under-ripe            | 12                 | 15.673 ± 0.315         | 26.618 ± 0.512          |
|                       | 36                 | 14.610 ± 0.446         | 24.889 ± 0.725          |
|                       | 60                 | 13.309 ± 0.239         | 22.756 ± 0.390          |
| Ripe                 | 12                 | 23.618 ± 0.354         | 39.548 ± 0.577          |
|                       | 36                 | 22.544 ± 0.410         | 37.800 ± 0.667          |
|                       | 60                 | 20.625 ± 0.323         | 34.678 ± 0.526          |
| Over-ripe             | 12                 | 22.795 ± 0.713         | 38.209 ± 1.160          |
|                       | 36                 | 21.485 ± 0.302         | 36.076 ± 0.490          |
|                       | 60                 | 20.218 ± 0.481         | 34.015 ± 0.782          |
| Fruit loose from bunches | 12             | 22.663 ± 0.376         | 37.995 ± 0.612          |
|                       | 36                 | 21.064 ± 0.359         | 35.392 ± 0.586          |
|                       | 60                 | 19.374 ± 0.377         | 32.642 ± 0.613          |

Note: different letters in each column indicate a significant difference at α = 0.05

Table 1 shows that the potential oil yield value based on the percentage of fruit is higher than the potential oil yield based on the percentage of FFB. The highest oil yield potential based on the percentage of fruit was seen in the treatment with the ripening level of ripe FFB with a storage time of 12 hours (39.548% ± 0.577) and the lowest on raw FFB with a storage time of 60 hours (22.756% ± 0.390). While the highest yield potential based on the percentage of FFB was in the treatment level of ripening of ripe FFB with a storage time of 12 hours (23.618% ± 0.354) and the lowest was on under-ripe FFB with a storage time of 60 hours (13.309% ± 0.239). The oil yield potential in sequence from the highest to the lowest is FFB which is ripe, over-ripe, fruits lose from the bunches, under-ripe and with a storage time of 12 hours, 36 hours, 60 hours. Based on the results of the analysis of variance (ANOVA), the oil yield potential based on the percentage of FFB and the percentage of fruit in each treatment also showed a significant effect.

The oil yield potential based on the percentage of fruit is higher than the potential oil yield based on the percentage of FFB. This is because palm fruit is lighter than FFB. The oil yield potential based on the percentage of FFB is obtained by calculating the oil content in the mesocarp x percentage of mesocarp/fruit x percentage of fruit/FFB minus the standard of oil loss. While the potential oil yield based on the percentage of palm fruit is obtained by calculating the oil/mesocarp content x the percentage of mesocarp/fruit minus the standard oil loss [11]. This can support the improvement of the process to increase yield by separating the palm fruit from its bunches before the next process which also increases the efficiency of the process which has never been done in a palm oil processing plant (CPO). The same results were also found in the analysis of variance (ANOVA) on the potential oil yield of palm oil, based on the percentage of fruit both from the level of ripening and the storage time affecting the potential oil yield of palm oil produced.

The difference in potential oil yields in the factor of the ripening level of the palm fruit and the length of storage time occurred because the oil content in mesocarp is not the same and has undergone changes. In figure 1, the ripe FFB is always higher in potency than the FFB, which is over-ripe; the fruit loses from bunches and under-ripe. The same pattern also occurs in figure 2, namely the potential oil yield
based on the percentage of fruit. It happened because ripe palm fruit has the maximum content of palm oil, while in crude palm fruit the oil content is still low and still experiences the process of forming oil in the mesocarp. In the fruits which are over-ripe or have fruits lose from the bunches, the oil in the mesocarp undergoes hydrolysis or oxidative damage, and this physical damage can accelerate the oil damage process due to contact with air. [18,19], palm fruit with ripening level that is ready to be harvested has a high oil content.

Likewise, the potential oil yield for the old storage factor (figure 1 and figure 2), the potential oil yield based on the percentage of FFB and the percentage of fruit has the same pattern, which shows that the longer the storage of FFB, the lower the yield potential. This is because the longer time of storage will cause the decrease of the oil in the mesocarp. It is due to oxidation or hydrolysis, the occurrence of material contact with the storage environment resulting in reduced oil content in the mesocarp. With the reduction in oil content, the potential for yield is also reduced. So that it can be said that the potential yield of CPO oil is directly proportional to the oil content in the mesocarp. Therefore, if the oil content is higher, the potential oil yield is also higher. [9,20,21], oil degradation resulted from oxidation and hydrolysis will be able to cause damage to oil molecules to form free fatty acids which can affect the quality and quantity of CPO products. Storage (at room temperature and 60°C) periodically causes oil degradation, increases oxidation which is characterized by the formation of hydroperoxide and the rate of oxidation increases again in oxidation [8].
The amount of oil that can be produced from palm fruit during the processing at the palm oil mill is called oil **rendement**, oil yield, OER (oil extraction rate) and this are different from oil content. Palm oil yield is known from the amount of palm oil obtained per unit of raw material in units of weight percentage. As for the potential yield, the percentage of oil content is reduced by the percentage of oil loss during the treatment process (the average standard of oil loss is 1.775%).

Although the potential for oil yield based on the percentage of FFB is lower than the percentage of palm fruit both in the treatment of the level of ripening and the length of storage time, the pattern of increase and decrease in oil yield potential are similar in which the longer the storage, the oil yield potential will decrease and the ripe FFB has the highest oil yield potential.

### 4. Conclusion

The ripening level of palm fruit bunches and storage time significantly ($\alpha = 0.05$) affect the yield potential both based on the percentage of fruit and the percentage of FFB. The potential yield value was based on the percentage of fruit higher than the oil yield potential based on the percentage of FFB. The highest oil yield potential based on the percentage of fruit found on ripe FFB with a storage time of 12 hours (39.548% ± 0.577) and the lowest on under-ripe FFB with a storage time of 60 hours (22.756% ± 0.390). While the highest potential oil yield based on the percentage of FFB was found on ripe FFB with a storage time of 12 hours (23.618% ± 0.354) and the lowest on under-ripe FFB with a storage time of 60 hours (13.309% ± 0.239). The pattern of increase and decrease in the yield potential both based on the percentage of fruit or FFB has similarities, namely the longer the storage time, the potential oil yield will decrease. The ripe FFB has the highest yield potential; the next is the over-ripe FFB, the fruit loose from bunches FFB and the under-ripe FFB. In sequence, the potential oil yield from the highest to the lowest is from ripe, over-ripe, fruit loose from bunches, and under-ripe FFB with a storage time of 12 hours, 36 hours, and 60 hours.

### References

1. Ali M A, Al-Hattab T A and Al-Hydney I A 2015 Extraction of date palm seed oil (Phoenix Dactylifera) by soxhlet apparatus *International Journal of Advances in Engineering & Technology* 8(3) 261–71
2. Corley RHV and Tinker P B 2016 *The Oil Palm* (Fifth) (West Sussex, USA: Blackwell Science
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