Introduction

The oil palm, *Elaeis guineensis* Jacq, is categorized as a monocot and it is derived from the inter-tropical humid forest in Central and West Africa. Currently, the plant is widely distributed in east-south Asia, especially in the archipelago region of Indonesia and Malaysia, as an industrial crop for vegetable oil products. Both countries provide a large supply of palm oils for use on the international market (Bakoumé, 2016; Luyindula, Mantantu, Muembo, Batanga, & Bois d’Enghien, 2016). A key factor for successful palm oil production is the selection of good plants to increase genetic value and eliminate unwanted alleles. Materials from the current plant are three times more productive than 30 years ago (Ithnin, Serdari, Abdullah, Kushairi, & Singh, 2017).

Differences observed in the exocarp colour (outer layer) of the oil palm fruit are caused by pigmentation which can be classified into three types, namely, nigrescens, virescens, and albescens. They are the oil palm fruit which are found naturally in some forests. Nigrescens type is the most common of the three. Although it is found as a small population, the characteristics of virescens are reported to be dominant. Oil palm producers, including Indonesia and Malaysia, use nigrescens then virescens type (Corley & Tinker, 2016). Other crop with exocarp colour differences reported on date palm (*Phoenix dactylifera*) (Hazzouri et al. 2015).

In the assumption of oil palm breeders, virescens oil palm type has no real economic value. Therefore, the nigrescens is more considered. However, the virescens gives a visual cue that fruits are ripe without waiting to detach. In 2010, Indonesian Oil Palm Research Institute (IOPRI) successfully planted an open-pollinated population of Cameroon oil palm. The population was characterized for virescens type frequency, as well as the bunch components, quantity and quality of crude palm oil. The virescens frequency per accession was sufficiently wide, ranging from 3.33-65.71%, and was affected by the parent type, nigrescens or virescens. Most of the virescens’s fruit form is observed to be of dura, except one sample, which was observed to be tenera. The mesocarp to fruit (MF) and industrial extraction ratio (IER) percentage are similar to the nigrescens dura, namely 37.7% and 9.5%, respectively. Its oil quality is better than nigrescens, and it has total carotene ranging from 155-1246 ppm. The oleic fatty acid is higher than 50%, and the palmitic is lower than 40%. Due to the ease of determining mature fruits, as well as the higher oil quality, virescens oil palm type is recommended to be introgressed in a breeding program.
Sundram, & Tan, 2000). Gene VIRESCENS (R2R3-MYB transcription factor) was discovered to have experienced mutation in five dominant alleles which disturbed the synthetic process of anthocyanin, assumed to be the cause of virescens type (Low et al., 2017; Singh et al., 2014). Whereas, albescens type is recognized by its very low carotenoid content, a pale colour and the fruit only being found as a dura form. This type is also hardly found (Corley & Tinker, 2016).

Most of oil palm breeders ignored the virescens type as it did not appear to give any real economic value and after all a work to identify the level of maturity of the fruit colour excorap was done using the System Using Multispectral Image Analysis in HSV (Ali, Hashim, & Hamid, 2020; Minakata et al., 2018; Setiawan & Prasetya, 2020; Zulkifli, Hashim, Raj, & Huddin, 2018). However, since mature virescens can be easier identified without waiting to detached, this has begun to change. The detached fruits are risky due to the increase of free fatty acid and it takes extra work to collect in harvest time (Singh et al., 2014). Some reports also suggested that virescens has been used as an herbal agent for various conditions (Alaribe, Anyakora, Emoghene, Ota, & De Waard, 2016; Bakoumé, 2016; Ogbuanu, Chime, & Nwagu, 2015).

In this paper we try to elucidate the incidence of virescens in an open pollinated population of oil palm that originated from Cameroon. As a relatively new collection of germplasm, understanding the segregation of virescens trait in some populations could increase the chance of assembling new plant material with pure virescens type by better methods. Finally, the phenotype of bunch components, quantity and quality of crude palm oil with regards to the economic value for national oil palm industries are also described.

MATERIALS AND METHODS

This research used an open pollinated oil palm population of Cameroon origin and the results were obtained from three trial gardens, namely MA24S, MA25S and BJ42S. The trials used lined plot design without replication and used population density of 143 trees/ha with total 2,034 trees. All trial gardens were planted in District of Simalungun North Sumatera, Indonesia. Observation was carried out at 8 years old after planting, started from July of 2018 to January of 2019. The climatic conditions in the District of Simalungun, generally are as follows: minimum air temperature was 21.4oC, maximum air temperature was 28.9oC, and average temperature was 24.2–25.3oC. The district of Simalungun is located in a tropical area with an average rainfall of 2,894 mm. During the dry month of July, average rainfall was about 176 mm. The greatest amount of precipitation occurs in October, with an average of 350 mm. Simalungun lies on 250-400 m from the sea level (www.en.climate-data.org).

Bunch Components and Oil Quantity

One hundred and ninety-six bunches from virescens type were successful harvested and analysed. The analysis of bunch components was conducted to understand the characteristics of fruit to bunch (F/B), the percentage of mesocarp to fruit (M/F), and the percentage of kernel to fruit (K/F). The oil quantity analysis was carried out using the Soxhlet method. The rate of oil content to bunch (O/B) was obtained by multiplication the percentage of fruit to bunch (F/B) x percentage of mesocarp to fruit (M/F) x percentage of oil to mesocarp (O/M). The rate of oil production (CPO) was obtained by multiplying fresh fruit bunch (FFB) production (t/ha) x Industrial Extraction Rate (IER) (percentage of oil to bunch (O/B) x correctional factor of 0.855). This observation was conducted based on standard observation method in IOPRI by adopting method presented by Corley & Tinker (2016).

Analysis of Fatty Acids

The composition of fatty acid was analysed using the GC (gas chromatography) method referring to AOCs Official Method Ce 1b-89 (AOCs, 2011). Only one mature fruit bunch was harvested from each tree and 30 fruits were randomly selected from which CPO oil would be extracted. Samples of oil were weighed for 0.025 g, and then put in vial flask, 0.5 ml of Na-methylate 5 N was added, sealed and vortexed for 2 minutes. Samples of oil were also added to 1 ml Iso-octane, vortexed for 1 minute, centrifuged for 10 minutes and a layer of 1 ml was used as a sample for the GC instrument. The column used for the GC was: DB 23 J&W Scientific, carrier Gas: hydrogen, detector temperature: 260oC, injector temperature: 260oC, column temperature 1: 170oC, ramp rate: 20oC/minute, column temperature 2: 180oC, iso time: 1oC/minute, column temperature 3: 182oC, iso time: 10oC/minute, final temperature column: 220oC and hold time: 2 minutes. The measured fatty acid content consisted of lauric (C12:0), myristic (C14:0), palmitic (C16:0), palmitoleic (C16:1), stearic (C18:0),
oleic (C18:1), linoleic (C18:20), alpha-linoleic (C18:3), arachidic (C20:0), and gadoleic (C20:1).

**Analysis of Total Carotene**

Total carotene was analysed by referring to MPOB Test Method p.2.6. part 2: PORIM Test Method 1985 and standard curve method. Before analysing, samples of carotene were prepared by melting CPI, weighing for 0.0400 g (4 decimal) of CPO, and pouring into a 10 ml measuring flask. Furthermore, N-hexane was added until limit and absorbance signs were read at a wavelength of 446 nm. Carotene content was calculated using the following formula:

\[
\text{Carotene content} = \frac{10 \times A \times 383}{W \times 1000} 
\]

Where:
- \(A\) = absorbance;
- \(W\) = sample weight (gr)

**Statistical Analysis**

Differences of bunch components, fatty acid content, and carotene among accessions were analysed statistically using general linear model univariate and probability interval; \(\alpha = 0.05\) and continued by Duncan’s test. Furthermore, analysis of Pearson correlation and normal distribution was conducted.

**RESULTS AND DISCUSSION**

**Frequency of Virescens Type**

The oil palm fruit of virescens was relatively easy to distinguish from nigrescens during observation. Bunch or fruit was recognized for green colour when it was immature, orange to green colour on tip of fruit when it was nearly mature, then full orange colour when it was fully mature. Mesocarp colour also changed at fruit maturity, from greenish and pale colours to full yellow and orange when it was mature for harvest (Fig. 1 and Fig. 2). Virescens oil palm type samples were observed twice, when its bunch was immature and when it was mature. However, virescens type was sufficiently observed once when it had mature and immature bunches demonstrated clear fruit colours at the same time (Fig. 3). Characteristics of same fruit colours were found by Luyindula, Mantantu, Muembo, Batanga, & Bois d’Enghien (2016) in the collection of oil palm of virescens type in Yaligimba (DRC) and these were similar to species of *Elaeis oleifera* of Barcelos et al. (2015).

The observation was successful in finding 57 oil palm virescens type derived from 12 accessions with clear characteristics and forming dura fruits and one tenera. A collection reported the existence of virescens pisifera oil palm with the character of female bunches always aborted (Murugesan, 2010). IOPRI has also identified a virescens type of pisifera oil palm in a new trial with similar characters (unpublished). Virescens pisifera is very rarely found in both forests and collection of genetic resources and called ‘Gracilinux’ by Chevalier during 1910. Therefore, reported vircences pisifera is considered a valuable genetic resource that is being further evaluated for utilization (Murugesan, 2010; Odenore, Eke, Asemota, & Shittu, 2015).

It was also understood that oil palm of virescens type was generated from both virescens parent and nigrescens parent, although the quantity was smaller for the nigrescens. Some of nigrescens parents were derived from accessions of CMR 17, CMR 20, CMR 26, CMR 27, CMR 55, CMR 67, CMR 72 and CMR 81. Pollen of virescens was found pollinating flowers of nigrescens and the dominance of virescens to nigrescens (Corley & Tinker, 2016) was considered responsible for results of this observation. Frequency of virescens type per accession ranged from 3.45 to 65.71% or only 2.8% per all planted accessions (Table 1). Corley & Tinker (2016) suggested that frequency of found virescens type ranged from some 0.5% in Nigeria forest to 0.7% in Angola forest, even Zeven (1972) reported that the frequency of virescens reached 50% in the Congo forest, then Rajanaidu (1986) found some 6% of virescens in the Cameroon forest.

**Components of Bunch and Quantity of oil**

This research was successful in observing nine phenotypes of 196 harvested bunches (Table 2). All the harvested bunches were obtained from 57 plants of Cameroon origin virescens type. The nine phenotypes are: weight of bunch and stalk, including percentage of fruit to bunch, mesocarp to fruit, kernel to fruit, oil to bunch, kernel to bunch, shell to fruit, and IER. The phenotype of bunch weight was more widely affected by the shape of the dura fruit than tenera form, and the weight of the stalk contributed about 9.78% of the weight. Phenotype of bunch weight had a mean of 9.2 kg, with maximal of individuals reached a mean of 20.87 kg. However, this research did not use an adequate experimental design for phenotype with low heritability, therefore
Fig. 1. Exocarp colour types of virescens and nigrescens at various stages of fruit maturity
| Immature mesocarp virescens types in pale yellow and green colours | Immature mesocarp nigrescens type from greenish purple to pale yellow colours. |
|---------------------------------------------------------------|-------------------------------------------------------------------------|
| Nearly immature mesocarp virescens type from yellow to orange colours | Nearly immature mesocarp nigrescens type from yellow to orange colours orange |
| Mature mesocarp virescens type in full orange colour | Mature mesocarp nigrescens type in full orange colour |

**Fig. 2.** Mesocarp colour types of virescens and nigrescens at various stages of fruit maturity
Fig. 3. Oil palm virescens type tree showing bunches at various stages of fruit maturity at the same time. Immature bunch (A), nearly mature bunch (B), and fully matured bunch (C).

Table 1. Frequency of virescens on oil palm Cameroon origin

| No. | Accession | Parent Region | Village * | Type of Fruit | Number of Plant | Number of Virescens | Frequency (%) |
|-----|-----------|---------------|-----------|---------------|-----------------|--------------------|---------------|
| 1   | CMR012D   | East MN       |           | Virescens     | 34              | 4                  | 11.76         |
| 2   | CMR017D   | East B        |           | Nigrescens    | 30              | 3                  | 10            |
| 3   | CMR020D   | East S        |           | Nigrescens    | 29              | 1                  | 3.45          |
| 4   | CMR022D   | East M        |           | Intermediate  | 18              | 1                  | 5.56          |
| 5   | CMR025D   | East ZN       |           | Virescens     | 47              | 19                 | 40.43         |
| 6   | CMR026D   | East Mb       |           | Nigrescens    | 12              | 1                  | 8.33          |
| 7   | CMR027D   | Centre F      |           | Nigrescens    | 30              | 1                  | 3.33          |
| 8   | CMR035D   | West ST       |           | Virescens     | 35              | 23                 | 65.71         |
| 9   | CMR055D   | East Mi       |           | Nigrescens    | 6               | 1                  | 16.67         |
| 10  | CMR067D   | East Bi       |           | Nigrescens    | 8               | 1                  | 12.5          |
| 11  | CMR072D   | Centre Y      |           | Nigrescens    | 2               | 1                  | 50            |
| 12  | CMR081D   | South K       |           | Nigrescens    | 7               | 1                  | 14.29         |
| 13  | 93 Accessions |          |           | Virescens and Nigrescens | 2.034 | 57 | 2.8 |

Remarks: * MN = Mongo-Nnam; B = Bangue; S = Salapoumbe; M = Moloundou; ZN = Zoulabot Nouveau; Mb = Mbet I; F = Famnasi; ST = Saleki (Tonga); Mi = Miang II; Y = Yoko; K = Kribi.
the data found to be rather bias for those traits.

The phenotype of bunch weight was found to have a low heritability value in oil palm than other phenotypes, because of great environmental factors (Din Amiruddin, Nookiah, Sukaimi, & Hamid, 2015). However, a report by Hazir & Shariff (2011) suggested that the mean bunch weight of virescens in Malaysia was 20.4 kg, with fruit weight of some 11.04 g.

Phenotype of mesocarp to fruit became a good indicator as selected trait because of economic value with high heritability in oil palm (Din Amiruddin, Nookiah, Sukaimi, & Hamid, 2015). The average percentage of fruit to bunch and mesocarp to fruit reached 65.39% and 37.7%, with maximum of individual reaching 70.85% and 59.6%, respectively. The relatively higher percentage of mesocarp to fruit trait indicated that there was an individual potential which could be selected as parents for breeding program. In addition, mesocarp to fruit was found to have a high correlation with oil content in this research (Table 3). Shape of dura form was reaffirmed by shell percentage per fruit reaching 60.61% with average 50.1% and IER only at 9.5%, although as individuals, it could reach a maximal value of 17.35%.

Quality of Oil
This research was also successful in observing ten parameters of fatty acids profile of crude palm oil such as lauric, myristic, palmitic, palmitoleic, stearic, oleic, linoleic, linolenic, arachidic, and gadoleic, also including total carotene contents (Fig. 4, Fig. 5 and Fig. 6). Bayona-Rodriguez & Romero (2019) reported that there were no significant differences in oil quality including fatty acid composition in bunch harvested during the wet and dry seasons. Based on this matter, this study only analysed one bunch in each sample. IOPRI has also analysed data on palm oil fatty acid composition in which bunches are harvested at various times and different season periods which show low standard deviation (unpublished).

The profile of fatty acids of virescens type was dominated by palmitic, linoleic, stearic and oleic with total ranging from 97.78-98.91%. It is similar to profile of fatty acids of *E. oleifera* population (Montoya et al., 2013; Siregar, Rahmadi, Wening, & Suprianto, 2018) and *Elaeis guineensis* nigrescen (Montoya et al., 2014), then followed by lauric, myristic, palmitoleic, linolenic, arachidic and gadoleic, with total ranging only from 1.09-2.22%.

Virescens population has sufficiently good potential, especially for traits of oleic acid percentage approaching and reaching more than 50% and having linoleic content of 6-8%. It also has a palmitic acid percentage under 40%. Those virescens individuals might be introgressed in breeding program due to the profiles of fatty acid and virescens type. Meanwhile, for total carotene, there are seven individuals with total content of carotene higher than 1000 ppm so that these were found acceptable to be introgressed in the breeding program.

The correlation between fatty acids and carotene are also similar to report by Montoya et al. (2013) and Siregar, Rahmadi, Wening, & Suprianto (2018). Negative correlation between oleic to palmitic and myristic are very significant but are not any significant to total carotene (Table 4).
### Table 3. Pearson Correlation of nine phenotypes of virescens bunches components

|                | Bunch | Stalk | Fruit to bunch | Mesocarp to fruit | Kernel to fruit | Oil to bunch | Kernel to bunch | Shell to fruit | IER |
|----------------|-------|-------|----------------|-------------------|----------------|--------------|----------------|---------------|-----|
| Bunch          | 1     | 0.9** | 0.18'          | 0.16'             | -0.09          | 0.12         | -0.03          | -0.12         | 0.12|
| Stalk          | 1     | 0.004 | 0.15'          | -0.05             | 0.06           | -0.05        | -0.13          | 0.07          |
| Fruit to bunch | 1     | -0.13 | 0.11           | 0.14'             | 0.39''         | 0.08         | 0.15'          |               |
| Mesocarp to fruit | 1     | -0.13 | 0.82''         | -0.17             | -0.92''        | 0.82''       |               |               |
| Kernel to fruit | 1     | -0.03 | 0.96''         | -0.27''           | -0.03          |              |               |               |
| Oil to bunch   | 1     | 0.003 | -0.79''        | 1''               |               |              |               |               |
| Kernel to bunch | 1     | -0.22'' | 0.004         |               |               |              |               |               |
| Shell to fruit | 1     | -0.79'' |              |               |               |              |               |               |
| IER            |       | 1     |                |                   |                |              |               |               |

Remarks: * = shows significance of p < 0.05; ** = shows significance of p < 0.01

![Fig. 4. Main fatty acids profile of virescens type](image.png)
Fig. 5. Minor fatty acids profile of virescens type

Fig. 6. Normal distribution of virescens type for total carotene
|          | Lauric | Myristic | Palmitoleic | Linolenic | Arachidic | Gadoleate | Palmitic | Stearic | Oleic | Linoleic | Carotene |
|----------|--------|----------|-------------|-----------|-----------|-----------|----------|---------|-------|----------|----------|
| Lauric   | 1      | 0.51**   | 0.18        | 0.15      | -0.16     | 0.05      | 0.32*    | -0.26   | -0.24 | -0.10    | -0.24    |
| Myristic | 1      | 0.05     | 0.16        | -0.25     | -0.07     | 0.55**    | -0.35`   | -0.5``  | -0.03 | -0.01    |          |
| Palmitoleic | 1     | -0.31`   | -0.28       | -0.27     | 0.36`     | -0.46``   | -0.29`   | 0.10    | -0.03 |          |          |
| Linolenic | 1      | 0.44``   | 0.22        | -0.22     | 0.39``    | -0.09     | 0.25     | 0.06    |       |          |          |
| Arachidic | 1      | 0.36`    | -0.58``     | 0.71``    | 0.17      | 0.31`     | -0.08    |         |       |          |          |
| Gadoleic  | 1      | -0.14    | 0.22        | -0.22     | 0.39``    | -0.09     | 0.25     | 0.06    |       |          |          |
| Palmitic  | 1      | 0.06     | 0.53``      | 0.03      |           |           |          |         |       |          |          |
| Oleic     | 1      | -0.40``  | 0.11        |           |           |           |          |         |       |          |          |
| Linoleic  | 1      | -0.03    | 0.11        |           |           |           |          |         |       |          |          |
| Carotene  |        |          | 1           |           |           |           |          |         |       |          |          |

Remarks: ** Significant correlation at 0.01 level (2-tailed); * significant correlation at 0.05 level (2-tailed)
CONCLUSION AND RECOMMENDATION

The virescens type from Cameroon frequency range from 3.45 to 65.71% per accession and can be produced both from parents of virescens and nigrescens type. Mature and immature bunch colour of virescens is easier to distinguish than in nigrescens, which is proven when observing sample. Virescens population has wider variation in total carotene and oleic acid traits compare to nigrescens. In a breeding program to produce new oil palm variety, the best virescens individuals could be utilised. Oil palm breeding activity such as pollen collection, female flower isolation, self-crossing, recombination with dura and pisifera elite should be carried out immediately.

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REFERENCES

Alaribe, C. S., Anyakora, C., Emoghene, E., Ota, D., & De Waard, M. (2016). GC–MS profile, anti-seizure and anti-pyretic activities of palm kernel nut oil and its isolate, N-Octanoic acid from specially breed palm kernel Elaeis guineensis. Nigerian Journal of Pharmaceutical Research, 12(2), 87–94. Retrieved from http://nigjpharmres.com/ojs/index.php/NigJPharmRes/article/view/37

Ali, M. M., Hashim, N., & Hamid, A. S. A. (2020). Combination of laser-light backscattering imaging and computer vision for rapid determination of oil palm fresh fruit bunches maturity. Computers and Electronics in Agriculture, 169, 105235. https://doi.org/10.1016/j.compag.2020.105235

AOCS. (2011). Official methods and recommended practices of the AOCS. (D. Firestone, Ed.) (6th ed., 2nd printing). Urbana, Ill.: AOCS. Retrieved from https://www.worldcat.org/title/official-methods-and-recommended-practices-of-the-aocs/oclc/840128901?referer=di&ht=edition

Bakoumé, C. (2016). Genetic diversity, erosion, and conservation in oil palm (Elaeis guineensis Jacq.). In M. Ahuja & S. Jain (Eds.), Genetic Diversity and Erosion in Plants (pp. 1–33). Cham: Springer. https://doi.org/10.1007/978-3-319-25954-3_1

Barcelos, E., de Almeida Rios, S., Cunha, R. N. V., Lopes, R., Moloike, S. Y., Babychuk, E., … Kushnir, S. (2015). Oil palm natural diversity and the potential for yield improvement. Frontiers in Plant Science, 6, 190. https://doi.org/10.3389/fpls.2015.00190

Bayona-Rodrigo, C. J., & Romero, H. M. (2019). Physiological and agronomic behavior of commercial cultivars of oil palm (Elaeis guineensis) and OxG hybrids (Elaeis oleifera x Elaeis guineensis) at rainy and dry seasons. Australian Journal of Crop Science, 13(03), 424–432. https://doi.org/10.21475/ajcs.19.13.03. p1354

Corley, R. H. V., & Tinker, P. B. (2016). The oil palm. West Sussex, UK: Wiley-Blackwell. https://doi.org/10.1002/9781118953297

Din Amiruddin, M., Nookiah, R., Sukaimi, J., & Hamid, Z. A. (2015). Genetic variation and heritability estimates for bunch yield, bunch components and vegetative traits in oil palm interspecific hybrids. Journal of Agricultural Science and Technology A, 5, 162–173. https://doi.org/10.17265/2161-6256/2015.03.002

Hazir, M. H. M., & Shariff, A. R. M. (2011). Oil palm physical and optical characteristics from two different planting materials. Research Journal of Applied Sciences, Engineering and Technology, 3(9), 953–962. Retrieved from https://maxwellsci.com/jp/abstract.php?id=RJASET&no=137&abs=17

Hazzouri, K. M., Flowers, J. M., Visser, H. J., Khierallah, H. S. M., Rosas, U., Pham, G. M., & Haider, N. (2015). Whole genome re-sequencing of date palms yields insights into diversification of a fruit tree crop. Nature Communications, 6(1), 1-11. https://doi.org/10.1038/ncomms9824

Ithnin, M., Serdari, N. M., Abdullah, N., Kushairi, A., & Singh, R. (2017). Biodiversity and conservation of Elaeis species. In M. R. Ahuja & S. M. Jain (Eds.), Biodiversity and Conservation of Woody Plants (pp. 245–272). Cham: Springer International Publishing. https://doi.org/10.1007/978-3-319-66426-2_9

Ithnin, M., Serdari, N. M., Abdullah, N., Kushairi, A., & Singh, R. (2017). Biodiversity and conservation of Elaeis species. In M. R. Ahuja & S. M. Jain (Eds.), Biodiversity and Conservation of Woody Plants (pp. 245–272). Cham: Springer International Publishing. https://doi.org/10.1007/978-3-319-66426-2_9

Low, E. T. L., Jayanthi, N., Chan, K.-L., Sanusi, N. S. N. M., Halim, M. A. A., Rosli, R., … Kushairi, A. (2017). The oil palm genome revolution. Journal of Oil Palm Research, 29(4), 456–468. https://doi.org/10.21894/jopr.2017.00016

Luyindula, N., Mantantu, N., Muembo, D., Batanga, R., & Bois d’Enghien, P. (2016). Some morphological
observations on albo-nigrescens, albo-virescens and virescens types of oil palm planted at Yaligimba (DRC). *World Journal of Agricultural Research*, 4(4), 114–118. Retrieved from http://pubs.sciepub.com/wjar/4/4/3/index.html

Minakata, K., Tashiro, K., Wakiwaka, H., Kobayashi, K., Misrom, N., Aliteh, N.A. and Nagata, H. (2018). Proposal of Fruit Battery Method for Estimating Oil Palm Ripeness. In *12th International Conference on Sensing Technology (ICST)*, Limerick (pp. 399-402). https://doi.org/10.1109/ICSensT.2018.8603621

Montoya, C., Cochard, B., Flori, A., Cros, D., Lopes, R., Cuellar, T., ... Billotte, N. (2014). Genetic architecture of palm oil fatty acid composition in cultivated oil palm (*Elaeis guineensis* Jacq.) compared to its wild relative *E. oleifera* (H.B.K) Cortés. *PLoS ONE*, 9(5), e95412. https://doi.org/10.1371/journal.pone.0095412

Montoya, C., Lopes, R., Flori, A., Cros, D., Cuellar, T., Summo, M., ... Billotte, N. (2013). Quantitative trait loci (QTLs) analysis of palm oil fatty acid composition in an interspecific pseudo-backcross from *Elaeis oleifera* (H.B.K.) Cortés and oil palm (*Elaeis guineensis* Jacq.). *Tree Genetics and Genomes*, 9, 1207–1225. https://doi.org/10.1007/s11295-013-0629-5

Murugesan, P. (2010, January-February). *Enriching oil palm industry*. *Indian Horticulture* (pp.16-18). Retrieved from https://www.researchgate.net/publication/310612772_Enriching_oil_palm_industry

Odenore, V. D., Eke, C. R., Asemota, O., & Shittu, H. O. (2015). Determination of phylogenetic relationship among oil palm (*Elaeis guineensis*) varieties with random amplified polymorphic DNA. *European International Journal of Science and Technology*, 4(2), pp.155-160. Retrieved from https://www.eijst.org.uk/images/frontImages/gallery/Vol_4_No._2/17._155-160.pdf

Ogbeani, C. C., Chime, C. C., & Nwagu, L. N. (2015). Physiochemical and fatty acid analysis of Viervescens (Ojukwu) oil and Nigrescens (ordinary) palm oil of *Elaeis guineensis*. *African Journal of Food Science*, 9(7), 400–405. https://doi.org/10.5897/ajfs2014.1254

Rajanaidu, N. (1986). The oil palm (*Elaeis guineensis*) collections in Africa. In *International Workshop on Oil Palm Germplasm and Utilization* (pp. 59–83). Kuala Lumpur, MY: Palm Oil Research Institute. Retrieved from https://agris.fao.org/agris-search/search.do?recordID=MY8705213

Sambanthamurthi, R., Sundram, K., & Tan, Y.-A. (2000). Chemistry and biochemistry of palm oil. *Progress in Lipid Research*, 39(6), 507–558. https://doi.org/10.1016/S0163-7827(00)00015-1

Setiawan, A. W., & Prasetya, O. E. (2020). Palm oil fresh fruit bunch grading system using multispectral image analysis in HSV. In *2020 IEEE International Conference on Informatics, IoT, and Enabling Technologies (ICIoT)*, Doha, Qatar (pp. 85-88). https://doi.org/10.1109/ICIoT48696.2020.9089431

Singh, R., Low, E. T. L., Ooi, L. C. L., Ong-Abdullah, M., Nockiah, R., Ting, N. C., ... Sambanthamurthi, R. (2014). The oil palm VIRESCENS gene controls fruit colour and encodes a R2R3-MYB. *Nature Communications*, 5, 4106. https://doi.org/10.1038/ncomms5106

Siregar, H. A., Rahmadi, H. Y., Wening, S., & Suprianto, E. (2018). Komposisi asam lemak dan karoten kelapa sawit *Elaeis oleifera*, interspesifik hibrida, dan Pseudo-backcross pertama di Sumatra Utara, Indonesia. *Jurnal Penelitian Kelapa Sawit*, 26(2), 91–101. https://doi.org/10.22302/iopri.jur.pkss.v26i2.44

Zeven, A. C. (1972). The partial and complete domestication of the oil palm (*Elaeis guineensis*). *Economic Botany*, 26, 274–279. https://doi.org/10.1007/BF02861041

Zulkifli, Z. M., Hashim, F. H., Raj, T., & Huddin, A. B. (2018). A rapid and non-destructive technique in determining the ripeness of oil palm fresh fruit bunch (FFB). *Jurnal Kejuruteraan*, 30(1), 93-101. https://doi.org/10.17576/jkukm-2018-30(1)-12