The study of carotene content and iodine value of oil from different ripening levels and storage duration of palm fresh fruit bunches

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Abstract. This research is needed because the palm fresh fruit bunches (FFB) from the plantation were ripening before processing and the length of time when they arrived at the plant, can vary. Therefore, it can affect carotene content and iodine value changes in the mesocarp. Also besides, FFB originating from oil palm plantations in the Ungaran region of Central Java, Indonesia has never been studied. The objective of the research was to examine the carotene content and iodine value in palm fruit bunches on the level of ripening, storage duration of fresh fruit bunch (FFB). A completely randomized design (CRD) with 2 factors was used in this study. The first factor was the level of ripening of palm fresh fruit bunches (FFB), namely: under-ripe, ripe, over-ripe, loose fruit from bunches and the second factor was the shelf-life of FFB, namely: 12 hours of storage, 36 hours storage, 60 hours storage. The research was conducted with 3 repeated treatments. The observed parameters were carotene content, the water content of mesocarp, and the iodine value. The data obtained were processed and analyzed using ANOVA and followed by Duncan (DMRT) at α = 0.05 using SPSS version 25. The results of the study showed that the level of ripening of palm fresh fruit bunches significantly (α = 0.05) affect the carotene content, water content and iodine value. The carotene content of palm fruit bunches from the lowest to the highest is under-ripe, loose fruit from bunches, over-ripe, ripe. For the highest to the lowest fruit mesocarp water content is under-ripe, ripe, over-ripe, loose fruit from bunches and the second factor was the shelf-life of FFB, namely: 12 hours of storage, 36 hours storage, 60 hours storage. The research was conducted with 3 repeated treatments. The observed parameters were carotene content, the water content of mesocarp, and the iodine value. The data obtained were processed and analyzed using ANOVA and followed by Duncan (DMRT) at α = 0.05 using SPSS version 25. The results of the study showed that the level of ripening of palm fresh fruit bunches significantly (α = 0.05) affect the carotene content, water content and iodine value. The carotene content of palm fruit bunches from the lowest to the highest is under-ripe, loose fruit from bunches, over-ripe, ripe. For the highest to the lowest fruit mesocarp water content is under-ripe, ripe, over-ripe, loose fruit from bunches. The highest amount of palm oil iodine was in ripe FFB and followed by over-ripe, under-ripe, loose fruit from bunches. Similarly, the storage duration indicated that there was a case against carotene levels, the water content of mesocarp and iodine value. At 12 hours of storage, carotene content, water content, and iodine value were higher than 36 hours and 60 hours storage.

1. Introduction

Chemical content in oil palm fruit can be influenced by several factors including the quality and type of plant seeds, how to cultivate, where to grow (climate), harvest and post-harvest. Likewise, changes in the
quality of fresh palm fruit bunches as a raw material in palm oil mills that produce crude palm oil (CPO) can occur due to storage and processing delays [1];[2]. Based on the Letter Decree of the Minister of Agriculture of the Republic of Indonesia in 2018, FFB will be processed at a palm oil mill a maximum of 24 hours after harvesting (Ministry of Agriculture of the Republic of Indonesia, 2018). In some companies after the FFB harvest, a maximum of 12 hours must have been processed. [3];[4], oil damage including existing components can occur due to oxidation and hydrolysis processes due to the storage, bad transportation systems. The quality component of palm oil in palm fruit is the carotene content and iodine number value. Carotene is a yellow to orange-red dye which causes the color of CPO, while the peroxide number indicates the unsaturation of the fatty acids that make up palm oil. In addition to storage, the level of maturity of FFB also affects the properties and components in it, including the composition of fatty acids, oil content, carotene content [4]. FFB that will be processed in oil palm mills must be optimally ripe, but the facts are that there are still under-ripe, over-ripe, and lose fruits. Palm oil consists of fatty acids - saturated and unsaturated fatty acids. [5];[6], the main components of crude palm oil (CPO) saturated fatty acids are palmitic fatty acid, stearic, myristic and unsaturated fatty acids are oleic fatty acids, linoleat.

The quality of palm fruit bunches produced from oil palm plants greatly influences the nature and amount of palm oil produced. After harvesting the plantations, including oil palm fruit bunches, are still undergoing a process of respiration and physiological activity that can cause changes in the components present in FFB between the carotene content and iodine number which is one of the parameters in determining the quality of oil contained therein. While the criteria for harvested FFB are those that are ripe optimally, usually the highest oil content is naturally followed by carotene content and the high unsaturation level of fatty acids. By accordance with SNI 01-2901-2006 that the standard quality of crude palm oil at iodine value is 50-55 g iodine / 100g, Codex, booth 210-1999 for carotene content of 500 ppm [7]. [8], Indonesian CPO carotene levels from 205 samples were 420 (range 138-611). [9];[10];[11];[12], there is a relationship between the age of the plant, the place of growth, the fruit-bearing the characteristics of the palm oil produced [13], the climate also greatly influences the production of palm fruit bunches and palm oil.

The problem is that not all FFB is harvested at an optimal level of ripening, there is still raw, over-ripe and even fruits that have been released from their mark naturally, at the level of maturity they certainly have different characteristics of iodine numbers and carotene levels. On the other hand, after harvesting there were FFBS which were not directly processed or delayed processing due to poor transportation problems often called restan, some were not taken directly to the factory that day due to poor transportation, due to the queue when entering the factory. The existence of these conditions can certainly affect the carotene content and iodine value (unsaturation of fatty acids) which are indicators of the quality of palm oil. Based on the Ministry of Agriculture Decree in 2018, FFB processed in the factory must not be more than 24 hours after harvest (Ministry of Agriculture of the Republic of Indonesia, 2018). Carotene is a non-triglyceride compound and includes minor components contained in palm oil which makes the color of palm oil yellow to reddish-orange. Carotene content in the age and condition of palm fruit (under-ripe, ripe, over-ripe and lose fruit from bunches) can certainly vary usually between 500 - 700 ppm [14];[15];[16].

Carotenoid components are α-carotenoids, β-carotenoids, γ-carotenoids and the highest is β-carotenoids. In palm oil there is a high content of yellow to red (anthocyanin, carotenoids) as an indicator of high natural antioxidant content, namely tocopherol or vitamin E which is an unsaturated hydrocarbon compound formed from 8 isoprene molecules and if the oil is hydrogenated the carotene is also hydrogenated so the intensity the yellow color is reduced. Damage to the carotenoids can be caused by the activity of oxidative enzymes and other oxidizing agents, the presence of storage, temperature, and water activity can reduce carotenoid levels[17];[18]. Physiologically, carotenoids can be used as conductors of electrons in photosynthesis. Carotenoid biosynthesis as a form of isoprenoid (isoprene derivative compounds) formation through the MEP pathway of a branch of the Calvin cycle, takes place in the
plastide. The level of unsaturation of palm oil is indicated by the value of iodine value, the higher the value of unsaturation is also higher, based on the SNI standard CPO iodine number is 45-46 \cite{7};[8]. The higher the value of the iodine number, the better this is because if it is used for cooking oil or its derivatives have a positive impact on human health. Another side with the presence of unsaturated fatty acids that have double bonds will be easily oxidized to produce hydroperoxide compounds as the primary product and if the damage continues, free fatty acids will form. For this reason, research is aimed at assessing changes in carotene, water and iodine levels at the level of maturity and duration of storage of oil palm fruit bunches.

2. Materials and Methods
The research material is oil palm fresh fruit bunches (FFB) harvested from oil palm plants (12 years old) in the SEAT garden, Ungaran, Central Java, Indonesia at the level of maturity (under-ripe, ripe, over-ripe and loose fruit from bunches). Under-ripe fruit bunches: no fruit loosed, ripe fruit bunches: fruit loosed 1-2 / kg of FFB, over-ripe fruit bunches: fruits that rip 3-4 fruits/kg of FFB, loose fruit from bunches: fruit that is released from its mark naturally \cite{14};[19].

A Completely Randomized Design (CRD) with 2 factors was used in this study. The first factor is the level of maturity of oil palm fresh fruit bunches (FFB), namely: Under-ripe, Ripe, Over-ripe, Loose fruit from bunches. The second factor is the shelf life of FFB, namely: 12 hours, 36 hours, 60 hours. Storage of FFB and loose fruit by placing it in an open place. The analysis of carotene content \cite{20}, iodine value \cite{21} and water content \cite{21}. Oil extraction according to the method of \cite{22} was modified, namely FFB palm fruit released from bunches manually, digested using a digester and hydraulic presses continued. The oil obtained is added with 1:1 hot water (water dilution) filtered and precipitated. Oil (upper part) is taken for analysis. The data obtained were statistically analyzed (ANOVA) and if there was a real effect continued with the Duncan test (DMRT) of 5\% \cite{23}.

3. Result and Discussion
Based on the results, the research on each parameter is presented in Table 1 as follows.

| Treatment                  | Carotene (ppm) | Moisture content (%) | Iodine Value |
|----------------------------|----------------|----------------------|--------------|
| Storage duration (hours)   |                |                      |              |
| 12                         | 458.550        ± 60.528 \textsuperscript{a} | 30.423 ± 2.016 \textsuperscript{a} | 48.184 ± 2.166 \textsuperscript{a} |
| 36                         | 427.505        ± 45.920 \textsuperscript{ab} | 27.820 ± 2.401 \textsuperscript{b} | 46.688 ± 1.985 \textsuperscript{a} |
| 60                         | 389.795        ± 47.453 \textsuperscript{b} | 24.756 ± 2.472 \textsuperscript{b} | 44.434 ± 1.632 \textsuperscript{b} |
| Level of ripening          |                |                      |              |
| Under-ripe                 | 386.912        ± 48.926 \textsuperscript{p} | 30.872 ± 2.163 \textsuperscript{p} | 45.295 ± 0.864 \textsuperscript{p} |
| Ripe                      | 474.069        ± 58.444 \textsuperscript{q} | 28.094 ± 2.756 \textsuperscript{q} | 49.330 ± 2.036 \textsuperscript{q} |
| Over-ripe                  | 432.425        ± 39.509 \textsuperscript{pq} | 26.377 ± 2.075 \textsuperscript{pq} | 46.247 ± 2.125 \textsuperscript{p} |
| Fruit loose                | 407.727        ± 49.810 \textsuperscript{p} | 25.321 ± 3.107 \textsuperscript{a} | 44.870 ± 1.768 \textsuperscript{p} |

Different letters in each column indicate a significant difference at $\alpha = 0.05$.

Table 1 shows the results of statistical analysis of carotene content (ppm), water content (%), iodine number in the treatment of the level of maturity and shelf life of FFB. It is known that the shelf-life treatment and the level of maturity of FFB affect the carotene content of palm oil, the water content of...
palm fruit and the iodine rate of palm oil in the mesocarp. The carotene content of oil, water content and iodine number will decrease when it is stored in a long periods. For more details explained in the following.

3.1. Carotene Content
It is shown (Table 1) that in the treatment level of maturity, the highest carotene content in ripe FFB compared to the order below that passes over-ripe and loose fruit (Figure 1a). This is due to the maximum level of maturity of the formation process of carotene is also maximal, whereas in raw FFB the process of formation of carotene still occurs. In the condition of FFB that passes over-ripe and loose fruit, the carotene formed has undergone a process of fading or damage that can be caused due to oxidation or microbial activity. Furthermore, the treatment of long-standing FFB shows that the longer storage duration, the carotene levels will decrease (Figure 1b). The decrease in carotene levels is due to the degradation of carotene due to oxidation process by oxygen coming from the surrounding air and also a microbial activity which causes the orange color of the characteristic carotene begins to be eliminated black due to the decay process. The content of dyes in materials (anthocyanins, carotenoids) can occur due to degradation due to degradation (heat, storage, process), the process of maturity and maturity of agricultural products [24];[14].

Based on the analysis of variant (ANOVA), the level of ripening of FFB and storage duration affected the carotene content and the results of Duncan analysis (DMRT) $\alpha = 0.05$ showed the storage duration of 12 and 36 hours the results were the same, but significantly different from those stored 60 hours. The ripe and over-ripe FFB showed the same levels but significantly different from the under-ripe, loose fruit (Table 1). The average carotene content did not meet the SNI standard which was at least 500 ppm.

3.2. Water content
The result of the treatment level of ripening of fresh palm fruit bunches (mesocarp) is depicted in Table 1. The highest water content was in raw conditions compared to the ripe, over-ripe and loose fruit (Figure 2a). This is due to raw FFB which is still the initial stage of biomass formation (carbohydrate, fat, protein), which is the process of anabolism through photosynthesis, whereas in loose fruit (the lowest), this is because catabolism has begun to occur through the process of respiration and oxidation so that the formation of water stops or less than those that evaporate and oxidize. [14], at the beginning of the process of fruit maturation will begin the formation of biomass accompanied by the formation of water, after which there will be a decrease in the formation of water. In the treatment of storage time (12, 36 and 60 hours) showed that the longer storage duration, the water content of palm fruit mesocarp decreases. This is
because during the storage process there is a process of respiration and evaporation of water, one of which is a decrease in water content (Figure 2b). [16];[9], reported that due to the storage of oil palm fruit bunches can reduce water content due to the process of respiration and water evaporation.

![Figure 2](image.png)

**Figure 2.** The relation between the level of ripening (a) and storage duration (b) FFB to water content.

Table 1 Duncan's analysis (DMRT) α = 0.05 shows the water content at the 12-hours storage duration is significantly different from that was stored for 36 hours, 60 hours. Under-ripe FFB moisture content is significantly different from ripe, over-ripe, loose fruits.

### 3.3. Iodine Value (IV)

The highest iodine number in the treatment of the ripening level of FFB was obtained in ripe FFB, then below that, the FFB was over-ripe, under-ripe and loose fruit (Figure 3a). This happens because in ripe FFB the process of formation of fatty acids (anabolism) through the photosynthesis process runs the most maximum so that the amount of saturated fatty acids (palmitate, myristate, stearate) and unsaturated are also formed maximally (oleic, linoleic, linolenic). In FFB which is still raw the formation of unsaturated fatty acids is still slightly compared to saturated fatty acids, while those that are too ripe and loose fruit from bunches iodine value are lower because unsaturated fatty acids in palm oil that have been oxidized by oxygen to form peroxide and free fatty acids.

![Figure 3](image.png)

**Figure 3.** The Relation between the level of ripening (a) and storage duration (b) FFB to iodine value.
The process of forming the fatty acids making up palm oil starts from photosynthesis, along with the development of the level of ripening, fatty acids (saturated and unsaturated) will continue to form [13],[25]. In the treatment period of storage FFB it also shows that the longer it is stored, the iodine value decreases (Figure 3b). This is due to the longer storage periods, the contact between the air and the material was longer, therefore oil damage due to oxidation is also higher. Thus, the component of unsaturated fatty acids that have double bonds will be reduced, consequently, the unsaturation is reduced. [26],[15], the oxidation process in oil, especially in the bonding of unsaturated fatty acids and if this happens it will reduce the unsaturation of the oil associated with iodine value.

Table 1 shows the highest FFB ripe iodine numbers and significantly different from under-ripe, over-ripe and loose fruit. Whereas the 12-hour shelf life has the highest iodine value and is significantly different from that stored for 36 hours, 60 hours.

4. Conclusion
It was concluded that the level of ripening (under-ripe, ripe, over-ripe, loose fruit from bunches) and storage duration (12, 36, 60 hours) of palm fruit bunches significantly (α = 0.05) influenced the carotene content, water content and iodine value. Ripe FFB is best based on the observed parameters. The longer it is stored there is a decrease in carotene content, water content and iodine value. The storage duration of 12 hours is still the best based on the parameters observed compared to those stored 36 hours and 60 hours.

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