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Mapping of Bruise of Oil Palm Fresh Fruit Bunch during Loading and Transportation from Field to Mill

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Abstract

Fresh fruit bunches (FFBs) are used as raw materials for palm oil, and their transport from a field is a critical step to maintain their quality. Fruit integrity should be maintained so the mill can efficiently obtain palm oil with less than 5% free fatty acid content. Physical treatments for FFBs during loading to truck bins and transport may cause physical injuries. This research aimed to map fruit bruises. The map can be used as a basis in managing transport of FFBs. Physical injuries were assessed by bruise index (BI), which was calculated by measuring the bruise area and weight of the fruit. The experiment was conducted in a completely randomized design (CRD) with five replications. The treatments included truck type (wood bin or steel bin), truck age (more and less than 5 years), and FFB position in the truck bin (bottom, middle, top layer, front, center, or rear). Data were described by graphical method and analyzed statistically with one-way ANOVA. Results indicated loosen fruits and increased bruising of matured fruits loaded to the truck bin. BI (1.97–2.07) was not significantly different among FFBs placed in different positions in the truck bin. Nevertheless, FFB at the middle position showed higher degree of bruising than FFBs at the other positions. Fruit bruise was more prevalent when FFBs were transported by an old truck (>5years) rather than by a young truck, with BI values of 2.01 and 1.82, respectively.

Abstrak

Pemetaan Tingkat Memar Tandan Buah Segar (TBS) Kelapa Sawit Selama Pemuatan dan Pengangkutan dari Lahan ke Pabrik. Tandan Buah Segar (TBS) adalah bahan baku minyak kelapa sawit, dan pengangkutannya dari lahan ke pabrik merupakan salah satu tahapan kritis dalam mempertahankan kualitasnya. Keutuhan buah harus dijaga agar pabrik minyak kelapa sawit (PMKS) dapat memprosesnya menjadi minyak berkadar asam lemak bebas (ALB) kurang dari 5% dengan efisien. Perlakuan fisik terhadap TBS selama pemuatan ke bak truk dan pengangkutan dapat menyebabkan kerusakan fisik. Penelitian ini bertujuan memetakan kerusakan (memar) buah selama proses muat-angkut. Peta ini dapat digunakan sebagai dasar pengelolaan transport TBS. Kerusakan fisik ini diindikasikan dengan indeks memar (IM), yang dihitung berdasarkan luas memar dan berat buah. Percobaan penelitian dilakukan mengikuti metode Rancang Acak Lengkap, dengan 5 ulangan setiap perlakuan. Perlakuan meliputi jenis bak truk (kayu dan baja), usia truk (lebih dan kurang dari 5 th), dan posisi TBS dalam bak truk (dasar, tengah, atas). Data disajikan secara grafis dan dianalisis menggunakan ANOVA satu arah. Hasil memperlihatkan bahwa terdapat kenaikan jumlah buah lepas dari tandan (membrondol) dan buah luka dengan semakin matangnya buah (fraksi semakin tinggi). Pada buah yang semakin matang, nilai titik runtuhan dan batas luluh biologis semakin rendah, dari 10 N sampai 190 N. Berdasarkan posisi TBS di bak truk, tidak tampak perbedaan kerusakan karena posisi TBS, di dasar bak, tengah, maupun di lapisan atas, yaitu IM berkisar 1.97-2,07. Buah cenderung rusak lebih berat bila diangkut dengan truk berumur tua (lebih dari 5 tahun) daripada dengan truk masih muda (< 5th), dicirikan dengan indeks memar 2,01 berbanding 1,82.

Keywords: oil palm, transportation, bruise

1. Introduction

Oil palm is an important commodity in Indonesia. In the first quarter of 2012, the amount of palm oil exported by the country reached 9.78 million tons, which are equivalent to US$9.95 billion; such amount was produced by 9,074,621 ha of oil palm plantations [1,2]. The CPO productivity potency was 10.6 tons/ha/year. The optimum output can be obtained when the quantity and quality of fresh fruit bunches (FFBs) used as oil palm raw material meet the standard. However, field conditions affect ideal handling of FFBs. In terms of quality, fruit bruise should be avoided because it rapidly increases free fatty acid (FFA) [3,4]. FFA content is a main standard parameter for assessing the quality of oil palm. The FFA content in FFBs should be less than 3% when they arrive to the mill to obtain oil palm with FFA of no more than 5% [5]. Corley et al. [6] stated that the FFA content in undamaged fruits increased by 0.1% within 24 hours. By contrast, Turner et al. [7] found that the FFA content in bruised fruit increased from 1% to 6% within 20 minutes. Manual and mechanical handling of FFBs during loading and transport may cause injuries or bruise on the fruits because of their large weight. In the delivery of FFBs to the mill, the two activities that potentially bruise the fruit are 1) the fall of FFBs in the truck bin and 2) shock and friction during transport. Given that wounds (bruises) of the oil palm fruit determine the quality and processing characteristics of palm oil, fruit bruising should be observed after harvest. This research aimed to map fruit bruises during transport of FFBs. The map can be used as a basis in designing suitable transport equipment and managing the transport system.

2. Materials and Methods

This research was conducted from May to August 2016 at PT. Samples were obtained from XXX, an oil palm plantation company in North Sumatera. FFBs were harvested and transported from the field to the crude palm oil mill by using trucks. Bruise or damage of the fruit was observed during transportation, from the fruit collection point (FCP) to the mill loading ramp. Transport of FFBs was conducted using two types of transport equipment. FFBs were placed at five different positions in the truck bin for observation.

Sample. Oil palm FFBs were used as the research object. Samples were randomly selected from FFBs harvested in the oil palm field. Five data were obtained taken from each transport treatment. FFBs transported were harvested at the second maturity level.

Methods. This research was conducted by applying two treatments of truck age, five treatments of bin position, and two treatments of truck type. Trucks used were aged less than or more than 5 years. The five positions in the bin included top layer, middle layer, bottom layer, front side, and rear position (Figure 1). The types of trucks used were wood bin and steel bin.

Data analysis. Data collected were analyzed statistically and presented graphically. Statistical methods used for comparison among the treatments were T-test and ANOVA. Degree of bruising was calculated by measuring the bruised area (cm^2) and the weight of fruitlets (g). Bruise index (BI) was used for classification and scored

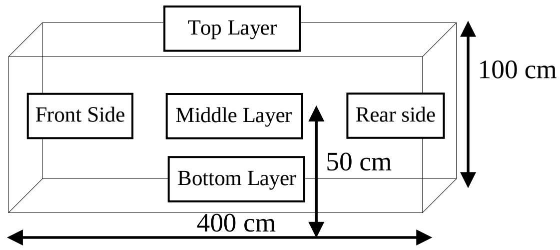

Figure 1. Positions of Oil Palm FFBs in Truck Bin as Research Treatment

as follows [8]: (a) sound fruits, no skin break, corresponding to BI of 1; (b) minor bruised fruits, total bruise area of less than 1 cm, corresponding to BI of 2.5; (c) moderate bruised fruits, total bruise area of 1–2 cm, corresponding to BI of 5.5.; (d) major bruised fruits, total bruised area of more than 2 cm, corresponding to BI of 10.

$$Bruise\ index = \frac{X1+2.5\ X2+5.5\ X3+10\ X4}{100} \quad (1)$$

where X_1, X_2, X_3, and X_4 are the percentage weights of the fruits with no bruises (a), minor bruises (b), moderate bruises (c), and major bruises (d), respectively. BI of 1 indicates that the entire lot consists of unbruised fruits, whereas BI of 10 indicates that the lot is made up of fruits with major bruises.

The experiment was conducted using a completely randomized design (CRD). Data were statistically analyzed with ANOVA and presented graphically.

3. Results and Discussion

Loading process. Loading into truck bins, especially manual loading, is a postharvest activity that has high possibility to bruise FFBs. A worker throws FFB to pass through the truck bin wall, which is 2.5 m in height. The FFB will drop to the truck bin, which is about 1.3 m in depth. FFB has a typical weight of 40 kg and is generally harvested from 20-year-old oil palm trees. The impact of dropping FFB may cause injuries or bruise. The degree of bruising will be higher when the FFB is dropped directly to the truck bin base. The upper layer drop impact was smaller because the fruit has spring characteristics [9,10]. This property provides cushion to the upper fruit to allow it to absorb the shock. In accordance with the results in Ref. [11], impact and absorbed energy are linearly correlated with fruit damage area. The difference is depicted in Figure 2.

The BI of FFBs transported by a steel truck bin was higher than that of FFBs transported by a wooden truck bin, regardless if the fruit was placed at the upper or bottom layer. This finding could be due to the hardness of the steel bin. Ref. [12] stated that the harder the base of a container is, the higher the damage to the FFB will be.

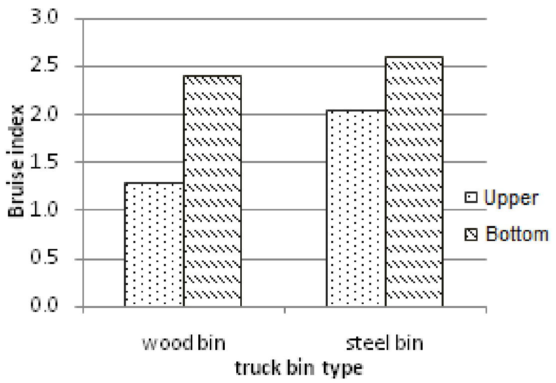

Figure 2. Bruise Indices of FFBs Loaded on Wooden and Steel Truck Bins

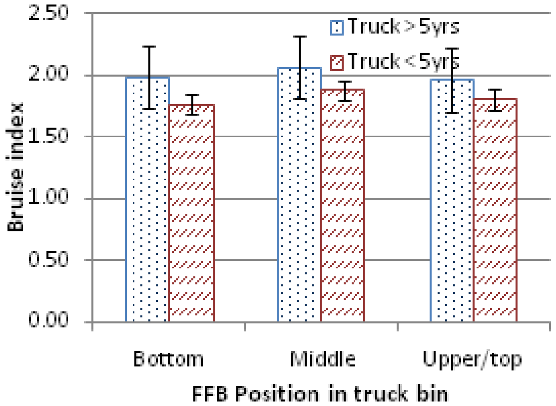

Figure 3. BIs of FFBs Loaded on Trucks Aged >5 Years and <5 Years

Hence, a trunk with a wooden bin is suitable for maintaining the quality of FFB, given that high BI will lead to high amounts of FFA released [13,14].

As a result of impact or friction, the soft cell wall will cause enzymatic, autocatalytic, and hydrolytic processes, which will rapidly increase the FFA content. Mangoensoekarjo, et al. [15] stated that FFB transport aims to maintain the daily FFA content between 2% and 3%. High FFA content causes oil to easily freeze at room temperature, thereby complicating the transportation [6].

Transportation process. BI was not significantly different among FFBs placed at the bottom, middle, and top layer in the truck bin. However, BI differed between FFBs loaded on old and new trucks (Figure 3). This finding could be due to the different vibration displacements between old and new trucks, with values of 1.27 and 1.37 mm, respectively. The older truck suffered spring and quality degradation of components, resulting in higher vibration frequency of 43.12 Hz compared with that of the young truck (32.85 Hz). The frequency of sinusoidal movement during transportation influenced the force that hit the fruit [16]. A high displacement also indicates high impact to the fruit when it reached the bin base. This condition led to a high degree of fruit damage, as indicated by BI (Figure 3).

Krisdiarto, et al. [17] found that BI was not significantly different among FFBs transported by roads of different qualities (good, moderate, and bad). By contrast, Krisdiarto, et al. [18] indicated that fruit loosening from FFBs placed on the bottom layer of the truck bin was higher than that from FFBs placed on the top layer. The oil palm fruit is a biological material that is vulnerable to impact and load. Load and friction among fruits during transport will damage the mesocarp, leading to rapid increase in the FFA level.

Figure 4 shows the mapping of the BI of FFBs transported from the FCP to the palm oil mill. Although BI was statistically not different among the samples, FFBs at the

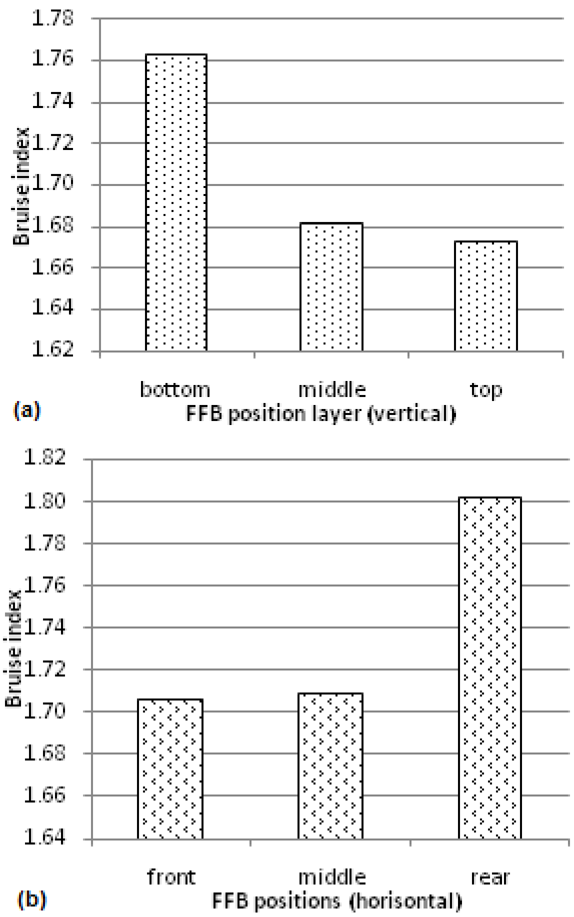

Figure 4. BIs of FFBs Placed at Different Positions in the Truck Bin: (a) Vertically Position and (b) Horizontal Position during Transport

bottom potentially suffered higher bruise than those at the other positions (Figure 4a). This finding could be due to the fact that FFBs placed at the bottom received higher pressure than those placed at the top. Moreover, FFBs placed at the rear part of the truck bin potentially suffered higher degree of bruising than those in horizontal part. This finding could be attributed to the higher displacement of transportation vibration at the rear part of the bin. The risk will be higher if FFBs are harvested at higher maturity levels because their mesocarps are softer [19]. Based on potential risk, if FFBs transported were mixed with those at the ripening level, the latter should be placed at the front edge and top of the truck bin.

4. Conclusion

FFBs may incur physical damages during their transport. In addition to the fruit maturity level, modes of transportation influence wound increment. Trucks with a wooden bin were better in keeping FFB quality than those with a steel bin. BI varies among FFBs placed in different positions in the truck bin. BI was high in FFBs placed at the bottom and rear position of the bin. Hence, matured FFBs should be placed at the front edge and top of the truck bin to maintain high quality during transportation.

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