The Feasibility of Sugar Palm (Arenga pinnata) Trunk for Raw Material of Parquet (Wood Flooring)

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Abstract. In the market, parquet was made from high density wood such as teak, merbau, kempas, ulin, oak, lime, maple, or other high density wood. Parquet has been used for flooring in specific buildings, for instance sport hall, library, commercial building (i.e hotel lobby, hypermarket), and office building. Because of the scarcity of high density wood nowadays and in order to find out the alternative material for wood flooring, the utilization of sugar palm trunk was considered. In this contribution, unproductive sugar palm tree was cut down and divided into three sections using chain saw, namely bottom, middle, and tip. For each section, physical and mechanical samples testing were made according to British Standard 373:1957 for small clear specimen. Investigation of both properties was done in ambient temperature with at least three replications. Instron UTM (Universal Testing Machine) was used to evaluate the mechanical properties. Results of the physical testing (density, moisture content and tangential shrinkage) showed the entire trunk was suitable for raw material of parquet. However, the results of mechanical testing (hardness, MOE/modulus of elasticity, MOR/modulus of rupture, and compression perpendicular to grain) showed only bottom and middle parts were suitable for raw material of parquet while the upper part was vice versa.

1. Introduction
Parquet is a wood flooring product which needs specific requirements such as high density and fantastic hardness values. These properties are faced to heavy-duty and residential building construction application in specific structure, for instance sport hall, library, commercial building (i.e hotel lobby, hypermarket), and office building [1]. Basically, there are two types of wood flooring according to their fabrication, namely solid wood and engineered wood flooring [2]. For the first, the entire trunk of parquet made of pure solid wood, while for the latter, engineered flooring consists of several layers of wood, 3/8 inch to 1/2 inch-glued together. The sheets could be either solid wood or panel products such as high density fibreboard or hardboard.

To date, commercial tropical and Latin America woods have been predominant raw material for parquet, such as merbau (Intsia sp.), doussie (Afzelia spp), kambala/iriko (Chlorophora exelsa), wenge (Millettia laurentii), ipe (Tabebuia impetiginosa) and jatoba (Hymenaea coubari) [3]. Furthermore, Gungor et al. [4] stated that wood flooring industry in Turkey have been used walnut, maple, cherry, iroko, sapele, merbau, doussie, teak, wenge, bubinga, birch, and ozigo woods for producing multilayered parquet.
In fact, parquet products distributed in Indonesia were made from high density wood originated from natural forests such as merbau, kempas, and ulin; man-made forest (Perum Perhutani) wood such as teak; and imported logs such as oak, lime, and maple. Nowadays, the supply of wood originated from natural forest is decreased both in the quality and the quantity because of forest conversion, fire, settlement necessity, and wood-industry needs. High density wood resources are also scarce and their cost are high because these typical wood are classified as slow grow species; they need long period of time for growing.

In this context, in order to seek other potential raw materials and to find out the alternative material for wood flooring, the utilization of sugar palm trunk was considered. Sugar palm is native in Indonesia and it has distributed extensively [5-7]. Even though sugar palm trunk has high density, the investigation on the feasibility of sugar palm trunk for raw material of wood parquet has been still needed. Traditionally, sugar palm trunk was only utilized for producing sugar palm (in Bolaang Mongondow, South Sulawesi) [7], agriculture tools (in Karo, North Sumatera) [8] and house wall (in Bajo, Central Sulawesi) [9].

The objective of this work was to determine qualitatively the physical and mechanical properties of sugar palm trunk according to British Standard that promoted potential raw material for wood flooring. More specifically, the work focused on understanding the feasibility of sugar palm trunk based on the position in the trunk.

2. Materials and Methods

2.1. Materials

In this contribution, unproductive sugar palm tree (about 15 years old) (Fig.1) was cut down and divided into three sections using chain saw, namely bottom, middle, and upper parts. Each section was split edge in order to get the outer part and then converted into test samples using band-saw (Fig.2). In fact, sugar palm stem was consisted of two parts, namely outer part (periphery) and central part (pith) [6]. Generally, the periphery has high density and hardness whereas the pith tends to brittle [10]. In this study, the periphery was utilized and British Standard containing methods of testing small clear specimens of timber (BS 373:1957) were used as the guideline of the physical and mechanical testing.

![Figure 1. Unproductive sugar palm tree as the materials in this study.](image1)

![Figure 2. Band-saw for making test specimens.](image2)
2.2. **Physical properties**

Investigation of physical properties was carried out in ambient temperature at Forest Products Laboratory, Faculty of Forestry, University of Sumatera Utara (Medan, Indonesia) with at least three replications, consisted of determination of density, moisture content (MC), and tangential shrinkage. Both density and MC specimen’s size were 2 cm x 2 cm x 2 cm. The dimension of test piece of shrinkage was 1 inch x 1 inch x 4 inch which the longest dimension was tangential direction. Weight and dimension were measured using electronic balance and callipers. Moisture content was determined by gravimetric analysis.

2.3. **Mechanical properties**

Hardness test was conducted using the Instron UTM (Universal Testing Machine) in ambient temperature for at least three replications. The dimension of the specimen was 2 cm x 2 cm x 6 cm which the longest dimension was longitudinal direction. The test requires the determination of the load necessary to force into test piece, to a depth of 0.222 inch using a steel ball with 0.444 inch diameter by loading rate of 0.25 inch per minutes.

Bending strength test was conducted using a span (28 cm) by central method of one point loading using load speed of 0.26 inch per minute in the room temperature with at least three replications. The size of the specimen was 2 cm x 2 cm x 30 cm which the longest dimension was longitudinal direction. In this condition, bending of MOE/ modulus of elasticity and MOR/ modulus of rupture was determined using UTM for the measurement as well.

Compression test perpendicular to grain was also conducted using the UTM in ambient temperature for at least three replications. The load was applied to the test piece (2 cm x 2 cm x 2 cm) at a constant head speed of 0.025 inch per minute. The load compression curve shall be plotted to the point when the compression of the test piece reached 0.1 inch.

All of the mechanical properties tests were conducted in Wood Engineering Laboratory, Faculty of Forestry, Bogor Agricultural University (Bogor, Indonesia). Typical of specimens and Instron UTM were presented in Figure 3 and 4.

![Figure 3. Specimens for the evaluation of physical and mechanical properties](image1)

![Figure 4. UTM for measuring mechanical properties](image2)
2.4. Data analysis
Mean value from at least three data measurements both on physical and mechanical properties testing were presented including their standard deviations. One way analysis of variance (ANOVA) was done in order to examine statistical significance at a p value of 0.05 for the factor of part of the trunk.

3. Results and Discussions

3.1. Physical properties
Table 1 shows values of physical properties of sugar palm trunk on various positions. Statistical analysis confirmed the position of the trunk resulted in significant influence on all the physical properties.

The density exhibited the high number on the bottom and middle part of the trunk. However, the upper part did not result in suitable number for wood flooring raw material. In other words, the upper part of the sugar palm trunk cannot be used for manufacturing parquet. Parquet will receive both dead and live load during life service. Hence value of the density of material for flooring should be more than 1.

The value of the moisture contents seemed similar for all of the position, around 15%. In relation with the tangential shrinkage, the upper part showed the highest shrinkage. This means the hygroscopic in the sugar palm trunk is predominantly in the upper part.

The low standard deviation obtained for the physical properties evaluated was also highlighted, since large deviations are commonly found when lignocelluloses materials are under consideration, and this is a characteristic always cited as one of the common detrimental of using lignocelluloses materials.

| Part of sugar palm trunk | bottom | middle | top |
|-------------------------|--------|--------|-----|
| Density (g/cm³)         | Mean   | 1.04*  | 1.02* | 0.68* |
|                         | SD     | 0.02   | 0.08  | 0    |
| Moisture Content (%)    | Mean   | 14.92* | 14.31* | 14.92* |
|                         | SD     | 0.56   | 0.43  | 0.76 |
| Tangential Shrinkage (%)| Mean   | 4.47*  | 3.71*  | 5.24* |
|                         | SD     | 0.57   | 0.13  | 1.25 |

3.2. Mechanical properties
Table 2 shows values of mechanical properties of sugar palm trunk on various positions. Statistical analysis confirmed the position of the trunk resulted in significant influence on all the mechanical properties as well.

| Part of sugar palm trunk | bottom | middle | top |
|-------------------------|--------|--------|-----|
| Hardness (kg/cm²)       | Mean   | 743.67* | 736.67* | 166.33* |
|                         | SD     | 231.20 | 57.42 | 58.77 |
| MOE (kgf/cm²)           | Mean   | 15.27 x 10⁴* | 12.43 x 10⁴* | 4.93 x 10⁴* |
|                         | SD     | 1.26 x 10⁴ | 7.73 x 10⁴ | 2.00 x 10⁴ |
| MOR (kgf/cm²)           | Mean   | 1231*  | 1129*  | 646*  |
|                         | SD     | 76     | 591    | 254   |
| Compression perpendicular to grain (kgf/cm²) | Mean   | 255*  | 304*  | 118*  |
|                         | SD     | 109    | 82     | 70    |
The hardness exhibited the high number on the bottom and middle part of the trunk. However, the upper part was vice versa. In other words, the upper part of the sugar palm trunk cannot be used for manufacturing parquet. Hardness is the most important factor to determine the suitability of the material for flooring. According to the European Standard for flooring, both bottom and middle parts of sugar palm trunk were classified as moderate application in level commercial use [11].

The values of the MOE, MOR, and compression perpendicular to grain also performed similar tendency with hardness. The bottom and middle position of the sugar palm trunk were potential as raw material for wood flooring. By contrast, the upper part of the trunk was not suitable for raw material of parquet.

It is worth saying that based on the evaluation of the physical and mechanical characteristics of sugar palm here, particularly on the outer part (periphery) on the bottom and middle parts of the trunk, sugar palm trunk is considered as a possible candidate for flooring raw material.

4. Conclusions
In accordance with physical and mechanical evaluation of sugar palm trunk, the bottom and middle part of the trunk can be used as raw material of wood flooring or parquet. Unfortunately, the upper part is not suitable for manufacturing of wooden parquet.

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