The physical characteristics of oil palm trunk and fast growing species veneer for composite-plywood

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Abstract. Oil palm trunk waste and fast growing species has potential to be used as composite-plywood (comply) raw material. Oil palm trunk as core layer and fast growing species as face and back layers of comply. This research focusing on the raw material characteristics of comply made of fast growing species (sengon, afrrika, acacia) and oil palm trunk waste. The aim of this research is to determine the physical properties of raw materials to be used as comply. The physical properties (moisture content, specific gravity and thickness variations) were determined based on British Standard (BS) 373:1957 and Japanese Agricultural Standard (JAS) SE 11:2003. The research results showed that bottom and middle parts of oil palm trunk have moisture content and specific gravity values of 47%, 33% and 0.4, 0.7 respectively. Whereas, values of moisture content and specific gravity fast growing species from bottom, middle and upper parts were 54%, 47%, 35% and 0.25, 0.22, 0.24, respectively for sengon wood, 148%, 120%, 66% and 0.39, 0.32, 0.37, respectively for afrrika wood, 80%, 79%, 76% and 0.59, 0.57, 0.59, respectively for acacia wood. The moisture content of fast growing species veneer for sengon, afrrika, acacia were 27.32%, 32.83%, and 27.67%, respectively. Thickness variation of fast growing species veneer for sengon, afrrika, acacia from bottom, middle and upper parts were 2.00, 1.96, 1.95 mm, 2.25, 2.20, 1.95 mm and 2.11, 2.09, 2.09 mm. All the above physical properties were suitable for comply raw material.

Keywords: physical properties, raw materials, fast growing species, oil palm trunk

1. Introduction

In 2016, prediction of oil palm plantations area reached 11,672,861 ha and production 33,500,691 tons [1]. Oil palm trunk waste reaches 60 million m³ per year from 12 million ha during rejuvenation. Oil palm trunk waste is one of the alternative raw material on wood processing industries that have not been utilized significantly in Indonesia. Previous research results shown that oil palm trunk has potential to be used as composite board’s material, including comply [2,3].

Comply is wood panel products consists of veneer as surface layers and wood particles as core layer that bonded with thermosetting adhesive. Previous research results shown that the utilization veneer layers on particleboard and oriented strand board (OSB) improving significantly the physical and mechanical properties of the board [4,5]. The research found that production of comply displayed better physical and mechanical properties compared with those of particleboard. However, up till now, research concerning comply is rare, especially research on comply made of oil palm trunk waste and fast growing species. In this case, innovation of comply development using agricultural waste especially oil palm trunk which has low dimensional stability is needed. Oil palm trunk waste will be used as core layer in strips form and veneer from fast-growing species.
Fast growing species can be used as an alternative veneer on comply product because it has short rotation and have sufficient harvest diameter. In addition, wood veneer has good rigid and strength properties. It was expected that it can increase comply physical and mechanical properties by utilizing oil palm trunk waste [6]. Utilization of fast growing species composite boards have been done as glued-laminated beams from small diameter fast-growing tree species [7,8], particleboards from fast growing species [9] and laminated composite panels from fast growing species [10]. Moreover, preservation of composite board or solid wood of fast growing species also affect to subterranean termites resistance of smoked glued-laminated lumber [11,12] and polystyrene-treated wood of tropical wood species [13]. Wood treated with borax, acetylation, polystyrene and smoke [14] affect feeding rate of termites in wood treated [15].

In this study, fast growing species were sengon (Falcataria moluccana), afrika (Maesopsis eminii Engl.) and acacia (Acacia mangium Willd.). This study is a first step of research entitled development of high quality composite-plywood made of oil palm trunk waste and fast growing species. Basic characteristic of each material to be used was required to determine for designing high quality comply. The aim of this study is to determine the physical properties of comply raw materials from oil palm trunk waste and fast growing species veneer.

2. Method
2.1. Material
Logs of sengon (Falcataria moluccana (L.) I.C. Nielsen), afrika (Maesopsis eminii Engl.), and acacia mangium (Acacia mangium Willd.) of 20-25 cm in diameter and oil palm trunk (Elaeis guineensis Jacq) of 60-65 cm in diameter collected from Bogor area. Logs of fast growing species were debarked and convert to 2 mm veneer thickness using spindless rotary machine. Each raw material was devided into 3 parts (bottom, middle, and upper).

2.2. Testing of raw material physical properties
The physical properties of raw materials were tested based on British Standard [16] and Japan Agricultural Standard [17]. The samples size of moisture content and specific gravity were 2x2x2 cm³. The samples were air dried to 12-14% and weighted to determine the initial weight and put in oven for 24 hours at 103±2 °C. After 24 hours, samples were weighted to determine the moisture content and specific gravity values.

Samples size of moisture content and thickness variation of veneer were 10 cm in length, 5 cm in width and 2 mm in thickness. Moisture content was determined using moisture meter at three points and veneer thicknesses were measured in six points. All of variables were measures in six replications.

3. Results and discussion
3.1. Moisture content (MC)
Based on the wood samples position in tree, the moisture content decreases from bottom, middle and upper part of the tree. This phenomenon was relatively shown the same tendency for sengon, afrika, and acacia. Bottom wood absorbs nutrients earlier and it was distributed to the whole part of the tree through water. Therefore, moisture content at upper parts was lower compared to the other parts. In axial orientation, moisture content variation of the living tree is also more pronounced, where an increase from bottom to the top of trees [18]. Moreover, the physical properties of wood influenced by its position (bottom, middle, upper) in tree as a consequence of the axial system functions related to the distance water movement [19]. Moisture content will decrease with oven or air-drying before it was made for a certain product. The higher of drying temperature will push out water faster from the wood [20].

Moisture content of oil palm trunk has different trend than moisture content of wood as shown in figure 1. Upper part has higher moisture content than those of others because it contains the parenchyma portion which tend to absorb much water higher compared to those of others [21]. Distribution of vascular bundle effected the properties of oil palm trunk [22].
3.2. Specific gravity
Specific gravity range and average of acacia, afrika, sengon and oil palm trunk were 0.57–0.59 with average 0.58, 0.32–0.39 with average 0.37, 0.22–0.25 with average 0.23 and 0.43–0.70 with average 0.57, respectively as shown in figure 2. The specific gravity was affected by site, climate, geographical location, species, genetics, silvicultural treatment, breeding etc. [23].

Specific gravity value in middle part for sengon, afrika, acacia and oil palm trunk is lower compared to those of bottom part. Upper part of tree consist of younger tissues that has thinner cell wall than middle and bottom parts. In previous research results shown that specific gravity of kemiri wood (Aluerites moluccana) decreased from bottom to upper part [24]. Sengon, afrika and acacia wood were suitable for veneer production. The range of specific gravity requirement for veneer production was 0.40–0.70 and preferable specific gravity range was 0.50–0.55 [25].

3.3. Veneer moisture content (MC)
The research results of moisture content value for each veneer as shown in figure 3. The moisture content range and average of sengon, afrika, and acacia veneer were 26.48%–28.20% with average 27.32%, 32.24%–33.56% with average 32.83% and 27.08%–28.65% with average 27.67%,
respectively. Veneer moisture content decrease from bottom to upper part all of fast growing species. Veneer of fast growing species performed lower moisture content than those of solid wood because it has thin thickness compared to those of solid wood, so it evaporate water faster than solid wood [26,27].

![Figure 3](image)
**Figure 3.** Histogram of veneer moisture content.

### 3.4. Veneer thickness variations

Figure 4 shows veneer thickness variations from sengon, afrika and acacia fast growing species. The research results show that thickness variations was not significantly difference among the produced veneer, eventhough they were produced from different stems position. Thickness variations ranged and average of sengon, afrika and acacia were 1.95–2.00 mm with average 1.97, 2.18–2.25 mm with average 2.21 mm and 2.09–2.11 mm with average 2.10, respectively. Smaller veneer thickness variations will lead to better physical and mechanical properties of the produced comply. Veneer thickness variations were significantly affected by the machinery precision and operator expertise [28]. In previous research, dimensional stability and mechanical properties of comply made from mersawa veneer and fast growing species core increased linearly with the increasing of the comply thickness [29].

![Figure 4](image)
**Figure 4.** Histogram of veneer thickness variations.
4. Conclusions

Based on the research results, it can be concluded that:

1. Bottom and middle parts of oil palm trunk have moisture content and specific gravity values of 47%, 33% and 0.4, 0.7 respectively.
2. The moisture content of fast growing species from bottom, middle and upper parts were 54%, 47%, 35% respectively for sengon wood, 148%, 120%, 66% respectively for afrika wood, and 80%, 79%, 76% respectively for acacia wood.
3. The specific gravity fast growing species from bottom, middle and upper parts were 0.25, 0.22, 0.24, respectively for sengon wood, 0.39, 0.32, 0.37, respectively for afrika wood and 0.59, 0.57, 0.59, respectively for acacia wood.
4. The moisture content of fast growing species veneer for sengon, afrika, acacia were 27.32%, 0.59, and 0.7 respectively.
5. Thickness variation of fast growing species veneer for sengon, afrika, acacia from bottom, middle and upper parts were 2.00, 1.96, 1.95 mm, 2.25, 2.20, 1.95 mm and 2.11, 2.09, 2.09 mm.
6. All the above physical properties of oil palm trunk and fast growing species were suitable for comply raw material.

References

[1] [BPS] Badan Pusat Statistik 2017 Statistik Perkebunan Kelapa Sawit Indonesia 2016–2018 (Jakarta (ID): BPS – Statistics Indonesia)
[2] Hermanto I, Massijaya M Y 2018 Performance of composite boards from long strand oil palm trunk bonded by isocyanate and urea formaldehyde adhesives. *IOP Conf. Ser.: Earth and Environ. Sci.* **141** 0120012
[3] Fridiyantri I, Massijaya M Y. 2018. Physical and mechanical properties of parallel strand lumber made from hot pre-pressed long strand oil palm trunk waste. *IOP Conf. Ser.: Earth and Environ. Sci.* **141** 012007
[4] Král P, Petr Klímek P, Mishra P K, Rademacher P, and Wimmer R 2014 Preparation and Characterization of Cork Layered Composite Plywood Boards *BioResources* **9**(2) 1977–85
[5] Biblis E J, Grigoriou A, Carino H 1996 Flexural properties of veneer overlaid OSB composite panels from southern yellow pine *Forest Prod J* **46**(4) 59–62
[6] Prayitno T A 2012 Kayu Lapis: Teknologi dan sertifikasi sebagai produk hijau (Yogyakarta: Graha Ilmu)
[7] Herawati E, Massijaya M Y, Nugroho N 2010 Performance of glue-laminated beams made from small diameter fast-growing species *Journal of Biological Sciences* **10**(1) 37-42
[8] Herawati E, Massijaya M Y, Nugroho N 2008 The characteristics of glued-laminated beams made from small diameter fast-growing species *10th World Conference on Timber Engineering* 2 635–640
[9] Hermawan D, Hadi Y S, Massijaya M S, Santoso A 2012 Binderless particleboard resistance to termite attack *Forest Products Journal* **62**(5) 412-415
[10] Hendrik J, Hadi Y S, Massijaya M Y, Santoso A 2016 Properties of laminated composite panels made from fast-growing species glued with mangium tannin adhesive *Bioresources* **11**(3) 5949–5960
[11] Hadi YS, Efendi M, Massijaya M Y, Pari G, Arinana 2016 Resistance of smoked glued laminated lumber to subterranean termite attack *Forest Products Journal* **46**(7–8) 480–484
[12] Hadi Y S, Efendi M, Massijaya M Y, Arinana, Pari G 2016 Technical note: Subterranean termite resistance of smoked glued laminated lumber made from fast-growing tree species in Indonesia **48**(3) 211–216
[13] Hadi Y S, Massijaya M Y, Arinana A 2016 Subterranean termite resistance of polystyrene-treatedwood from three tropical wood species *Insects* **7**(3) 37
[14] Hadi Y S, Masijaya M Y, Hermawan D, Arinana A 2015 Feeding rate of termites in wood
treated with borax, acetylation, polystyrene, and smoke Journal of the Indian Academy of Wood Science 12(1) 74-80
[15] Hadi Y S, Massijaya M Y, Arinana A 2014 Technical note: Feeding rate as a consideration factor for successful termite wood preference tests Wood and Fiber Science 46(4) 590–593
[16] [BS] British Standar 1957 Methods of Testing Small Clear Specimens of Timber (London (GB): Timber Industry Standards Committee) 373
[17] [IAS] Japanese Agricultural Standar 2003 Japanese Industrial Standar: Plywood JAS SE-1. (Japan: Japanese Industrial Association)
[18] Tsounis G 1991 Science and Technology Wood. Structur, Properties Utilization (USA: Van Vostrand Reinhold Inc)
[19] Rowell R M 2005 Second Edition: Handbook Of Wood Chemistry And Wood Composites (Boca Raton. FL: CRC Press)
[20] Mochsin, Usman F H, Nurhaida 2014 Stabilitas dimensi berdasarkan suhu pengeringan dan jenis kayu. Jurnal Hutan Lestari 2(2) 229–241
[21] Prayitno T A 1991 Palm Wood Utilization, Sago Properties and Its Utilization IDRC – GMU Project Report
[22] Darwis A, Ridho Nurrochmat D. Massijaya M Y, Nugroho N, Alamsyah E M, Tri Bahtiaran W, Safe’i R 2013 Vascular bundle distribution effect on density and mechanical properties of oil palm trunk Asian Journal of Plant Sciences 12(5) 208–213
[23] Haygreen J G, Bowyer J L, Shmulsky R 2007 Forest products and wood science fifth edition USA
[24] Simangunsong A S, Hapud A, Muthmainnah 2016 Variasi sifat fisika kayu kemiri (Aluerites moluccana) berdasarkan arah aksial. Warta Rimba 4(1) 16–20
[25] Siska G, Supraptono B, Budiars E 2012 Variasi struktur anatomi, fisika, dan mekanika kayu pupu pelanduk (Neoscorthechinia kingie Hook.F.) (Pax Hoffm.) family euphorbiaceae dari Kalimantan Tengah Jurnal Kehutanan Tropika Humida 3(2) 118–126
[26] Komariah R N, Hadi Y S, Massijaya M S, Suryana J 2015 Physical-mechanical properties glued laminated timber made from tropical small-diameter logs grown in Indonesia J. Korean Wood Sci. Technol 43(2) 156–167
[27] Darmawan W, Nandika D, Massijaya M Y, Kabe A, Rahayu I, Denau L, Ozarska B 2015 Lathe checks characteristics of fast growing sengon veneers and their effect on LVL glue-bond and bending strength. Journal of Materials Processing Technology 215 181–188
[28] Tomppo L, Tiita M, Lappalainen R 2009 Ultrasound evaluation of the lathe check depth in birch veneer. Eur J Wood Prod. 67 27–35
[29] Massijaya Y M, Nuryawan A, Assyh N 2005 Fundamental properties of com-ply made of small diameter fast growing species and mersawa veneer. Proceedings of scientific session 90 “Using composites as a tool for a sustainable forestry” XXII IUFRO World Congress “Forest in the Balance” Brisbane, Australia 86–91

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