IOP Conference Series: Earth and Environmental Science

PAPER • OPEN ACCESS

The physical properties of densified Terentang wood (*Campnosperma auriculatum* (blume) hook. f) on various boiling and pressing time

To cite this article: E Sribudiani *et al* 2019 *IOP Conf. Ser.: Earth Environ. Sci.* **374** 012047

The physical properties of densified Terentang wood (*Campnosperma auriculatum* (blume) hook. f) on various boiling and pressing time

E Sribudiani[1], S Somadona[1] and G P Manalu[2]

[1] Lecturer of Department of Forestry, Faculty of Agriculture, University of Riau
[2] Student of Department of Forestry, Faculty of Agriculture, University of Riau

E-mail: sribudiani_unri@yahoo.co.id

Abstract. The fulfillment of the need for wood at this time can only use wood from industrial park forests and community forests, in which the type of wood is fast-growing wood. One of these fast-growing woods is Terentang wood where this wood belongs to the strong class III to IV. To increase the strength of Terentang wood,in this case, the physical nature of the innovation needs to be done using one of the technologies that havethe potential to improve the quality of wood, which is compaction or wood compression. The results of compaction of Terentang wood process with boiling treatment which has a better value of control are the properties of moisture content and specific gravity, the development and shrinkage of dimensions which arestill low compared to controls. The moisture is influenced by boiling time, pressing time, and interaction both of that. The specific gravity is affected by boiling time, the development of wood is influenced by boiling time and interaction of boiling and pressing time, shrinkage is affected by boiling time.

1. Introduction

Since a decade back, the legal harvesting of natural forests has almost no longer existed because there is a prohibition to exploit natural forests so that the need for wood from natural forests with strong and durable class quality is usually very difficult to obtain. Fulfilling the need for wood at this time can only use wood originating from industrial parks and community forests, in which the type of wood is fast-growing wood. One of the fast-growing woods that are abundant in Riau is stretched wood [1]. Stretched wood is classified as strong in class III to IV [2], this problem makes stretched wood rarely used by the community. To meet the community's need for quality wood, efforts to improve the quality of wood need to be carried out. One effort that can be done is compaction of wood [3].

Compaction of wood has been shown to improve some physical and mechanical properties of wood species, namely: Pulai [4], jati cepat tumbuh [5], mahang [6], tarap [7], and many others. Therefore, it is necessary to conduct research on "Physical Properties of Terentang Wood (*Campnosperma auriculatum)* Integrated by Boiling and Pressing Time".

The purpose of this research wasto determine the effect of boiling time and duration of pressing on the physical properties of Terentang wood.

IOP Conf. Series: Earth and Environmental Science **374** (2019) 012047 doi:10.1088/1755-1315/374/1/012047

2. Materials and methods

This research was carried out at the Woodworking Workshop, the Wood Base Laboratory, the Wood Building Design Engineering Laboratory, and the Biocomposite Laboratory, the Department of Forest Products, the Faculty of Forestry, Bogor Agricultural University.

2.1. Materials and tools

The material used in this study wasTerentang wood (*Campnosperma auriculatum)*. The tool used was hot press brand weili China, table saw brand Stanley, water bath brand Merrmer China, oven brand Binder Indonesia, desicator, calipers Krisbow China, digital scales brand Kren Jerman, universal testing machine brand Chunyen Taiwan.

2.2. Research methods

The research method used was factorial experiments in a Completely Randomized Design (CRD) with two treatment factors, namely boiling time (Factor A) and pressing time (Factor B). The treatment factor for boiling time consisted of three levels, namely: 60 minutes (A_1), 90 minutes (A_2), dan 120 minutes (A_3). The treatment pressing time factor consisted of three levels, namely: 10 minutes (B_1), 20 minutes (B_2), dan 30 minutes (B_3). This study used nine combinations of treatments with one control. Each treatment combination was carried out threetimes.

2.3. Research implementation

2.3.1. Material collection preparation and test sample preparation. The research material was taken from Bengkalis, Riau Province. The initial research material was a board with thesize of 32 cm (L) x 10 cm (W) x 2 cm (H) as many as 30 boards. Each piece was coded and painted on both ends to prevent excessive evaporation of water and fungal attacks. Next, the Terentang wooden board was dried using an oven to reach 12% -18% moisture content. Then the densification was carried out following the work procedures.

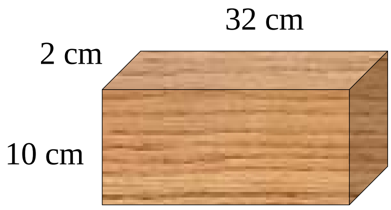

Figure 1. Test sample.

2.3.2. Boiling and pressing wood process. The boiling and pressing wood process refer to the research procedure carried out by Sulistyono [3] as follows:

1. Wood samples were dried to air dry (moisture content 12-18%) and measured in dimensions and initial weight before boiling.
2. Boiled wood samples used water media in waterbath with 60, 90 and 120 minutes respectively with boiling temperature of 100 °C.
3. After boiling, the sample was immediately wrapped in aluminum foil to keep the sample temperature hot and undamaged (burnt).
4. Pressing was carried out in the radial direction (figure 2) and pressurized at 2,33 MPa with a compression temperature of 125 °C in 10, 20 and 30 minutes.
5. The samples were pressed, then the dimensions were measured and weighed, and the air was dried for seven days.
6. Pression results were then made a test sample for testing physical properties (moisture content, specific gravity, and dimensional changes).
7. Test samples were made referring to British Standard Methods 373 [8].

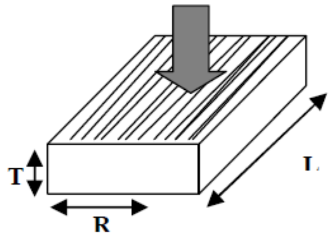

Figure 2. Compression wood directions.

2.3.3. Testing the physical properties of wood. Testing the physical properties of wood was carried out in test samples with boiling time variation (A): (A_1= 60 minutes), (A_2= 90 minutes), (A_3= 120 minutes), and pressing time (B): (B_1= 10 minutes), (B_2= 20 minutes), (B_3= 30 minutes). Nine variations of test samples (A_1B_1, A_1B_2, A_1B_3, A_2B_1, A_2B_2, A_2B_3, A_3B_1, A_3B_2, A_3B_3) were tested for physical properties with the following information:

a. Moisture content
The test sample used was2 cm x 2 cm. Examples of the test were dried in an oven at a temperature of 103°C±2°C until reaching a fixed weight. Then, the calculation wasdone with the following equation:

$$\frac{\textit{Initial Weight of wood (IW)- Dry Weight of Furnace (DWF)}}{\textit{Dry Weight of Furnace (DWF)}} \times 100\% \tag{1}$$

b. Specific gravity
The test sample used was 2 cm x 2 cm. Specific gravity was calculated by the equation:

$$\frac{\text{density of object (gr /cm}^3\text{)}}{\text{density water (1 gr /cm}^3\text{)}} \tag{2}$$

c. Swelling – shrinkage of wood
The test sample used was 10 cm x 2 cm. To get the dimension swelling value, first, the wood test sample was measured in its initial dimensions and then soaked for 24 hours. Furthermore, the dimension swellingwasmeasured by the following equation:

$$\frac{\text{Initial dimensions - Final dimension (mm)}}{\text{Final dimension (mm)}} \times 100\% \tag{3}$$

The dimensions were measured to find out the development of test samples of wood dimensions shrinkage by measuring dimensions before oven to determine the initial dimensions of air dry. After being an oven for 24 hours with temperature (103 ± 2) °C, then the wood is measured again to find out the final dimensions of the oven dry. Furthermore, the wood dimension shrinkage was calculated by the equation:

$$\frac{\text{Initial dimensions - Final dimension (mm)}}{\text{Final dimension (mm)}} \times 100\% \tag{4}$$

2.4. Data analysis
The data obtained was done with descriptive statistical methods using microsoft excel software. Furthermore, the data were processed using a linear additive model for a two-factorial complete randomized trial design.

$$Y_{ijk}= \mu+ \alpha_i+\beta_j+(\alpha\beta)_{ij}+\varepsilon_{k\,(ij)} \tag{5}$$

Y_{ijk} = Observation value on factor A treatment (boiling time) level i, and factor B treatment (pressing time) level j
μ = General average
α_i = Effect of boiling time factor (A) level i
β_j = Effect of pressing time factor (B) level j
$(\alpha\beta)_{ij}$ = Interaction of factor A at level i and factor B at level j
$\varepsilon_{k\,(ij)}$ = Effect of experimental error from the treatment factor A level i, and treatment factor B level j

Furthermore, analysis of variance was carried out with the calculated F test. If from the F count there is a real effect from boiling and pressing time, the average difference test between the treatments will be done using the average test of Duncan’s New Multiple Range Test (DNMRT).

3. Results and discussion

3.1. Physical properties of integrated Terentang Wood

3.1.1. Moisture content. The moisture content of Terentang wood had a smaller value than control wood. Its moisture content ranged from 7,488% to 10.322%, while control wood moisture content was worth 12,258%. Its howed that wood densification techniques could increase wood quality regading the moisture content. The following are the test results of the moisture content of Terentang wood based on the tests carried out.

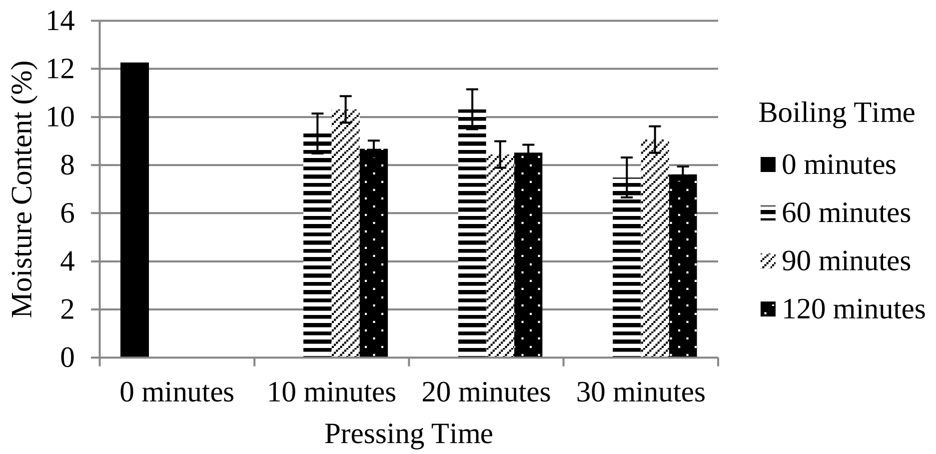

Figure 3. Moisture content of Terentang wood.

The test results of densification Terentang wood showed that the longer the time of the press, the denser the stretched water content of the stretched wood is also less. It is consistent with the research of Megawati et al. [9] showing that moisture content tends to decrease if pressuring is carried out in a longer time. The results of the analysis of variance found the boiling time, pressing time, and that interaction had a real impact on moisture content of densely stretched Terentang wood. Duncan's comparative test found that during compression time, the control was significantly different from times of 10, 20 and 30 minutes. The 10-minute compression was not significantly different from the 20-minutes, but the difference was between 30 minutes. Compression in 30 minutes was signicantly different from compression of 10 and 20 minutes.

The lowest moisture value is found in boiled wood for 120 minutes. It is suspected that this occurs because wood boiled for 120 minutes is softer (elastic) than boiled wood for 60 minutes and 90 minutes.

This supposition is supported by the statement of Sulistyono [3], boiling causes hemicellulose and lignin as the main components of binding and cellulose fillers, gradually from the hard from like glass turns closer to the elastic form like rubber. Increasing elasticity of wood will affect the compression. The interaction between boiling time and pressing time showed a significant effect on water content. The results obtained on moisture content decreased with increasing boiling time and pressing time. The elastic wood will be easier to compact and become flat. The flaking of wood is in line with the reduction in moisture content. This is the reason for wood which boiled 120 minutes and pressed 30 minutes has the lowest measure content.

3.1.2. Specific gravity (SG). Specific gravity of Terentang wood had better value than control wood. Specific gravity of compressed Terentang wood ranged from 0.79 to 0.995, while SG of control wood was 0.492. Test results can be seen in figure 4 below.

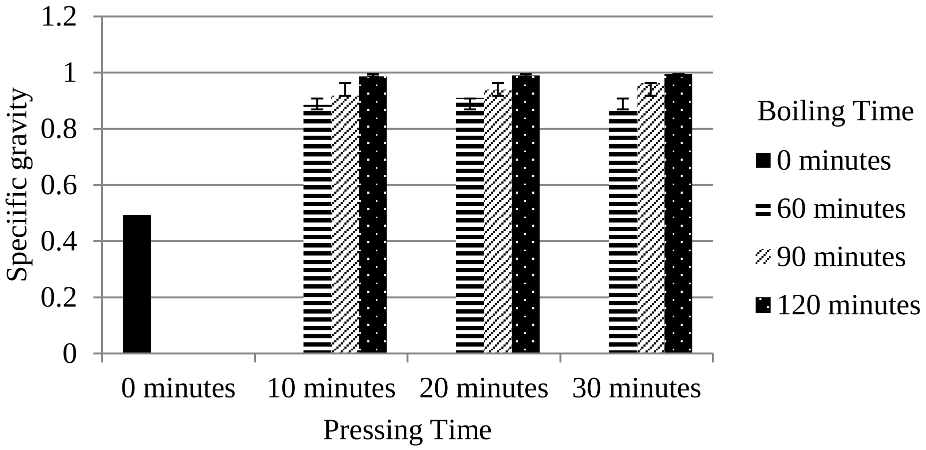

Figure 4. Specific gravity of Terentang wood.

In the SG, test results found that Terentang wood which was boiled 120 minutes had a greater SG value than the one with boiling time of 60 minutes and 90 minutes. It was because Terentang wood boiled 120 minutes was softer so that when compressed, Terentang wood did not experience significant damage. It is also in accordance with Sulistyono et al. [10] where boiling will soften the matrix so that hemicellulose and lignin as its main components become elastic and free from strain and tense.

Terentang wood compressed with a 30-minute pressshowedbetter SG results than the one compressed for 10 and 20 minutes. Besides, based on the results of the test, it was also found that the SG value of compressed Terentang wood increased by twotimes compared to the control, so that the compression technique also improved the quality of Terentang wood concerning SG. When compressed, the wood's porosity decreased, because the wood cells united one with another. It also causes the wood to become tight and dense, and the size of the wood volume decreases. Itis in accordance with Sulistiyono et al. [10] who suggested that pressures on wood without damaging excessive wood structure could compress wood and make wood denser so that the volume of wood be comes smaller, causing specific gravity to increase. Aribowo [11] also suggested that denser wood has a higher density value. The macroscopic observations made on compacted wood can be seen in figure 5 below.

The result of SG anova of pressing Terentang wood test found that boiling time affected the SG of compressed terentang wood, while the press time and interaction did not significantly affect the compressed wood press. In the Duncan bench marking test, it was found that the boiling time of 60 minutes, 90 minutes and 120 minutes was significantly different from the control, then the 60 minutes boiled time was not significantly different from the 90 minutes boiled time, but significantly different from 120 minutes boiled. Boiled 90 minutes is not significantly different from boiling 120 minutes. While the press time of 10 minutes, 20 minutes and 30 minutes was significantly different from the control.

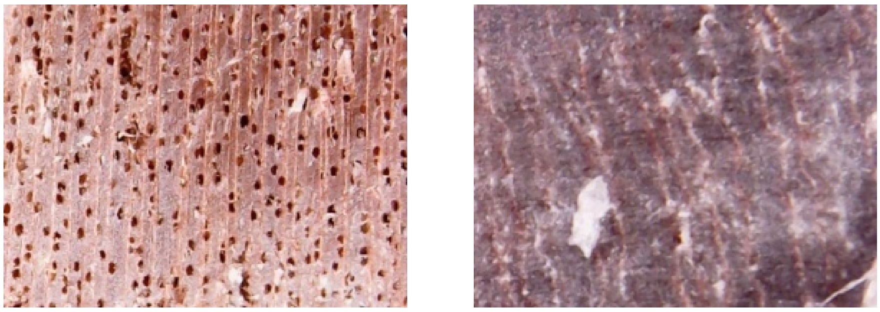

Figure 5. Macroscopic observation of Terentang wood (a) before being boiled and pressed and (b) after boiling and pressing.

3.2. Swelling – shrinkage of wood

3.2.1. Dimension swelling. Dimensional swelling of compressed Terentang wood had a higher value than Terentang wood which was not pressed. The dimensions of Terentang wood which was pressed ranged from 16.109% to 33.625%, while the development of Terentang wood dimension that was not compressed was 7.195%. The results of development of Terentang wood dimension based on the tests carried out are as follow:

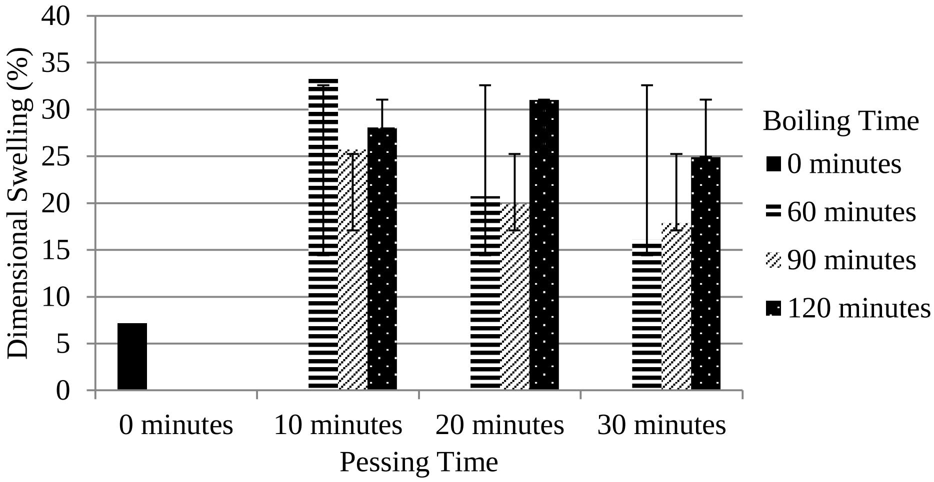

Figure 6. Dimensional swelling of Terentang wood.

The high dimensional swelling of compressed wood was caused by the elasticity of wood due to boiling and pressing treatment below the proportional point. Boiling softens the matrix so that hemicellulose and lignin become elastic and free from internal stress, while pressing below the proportional point is done to avoid damage to the wood due to compression. This suggest is in accordance with Amin and Dwianto [12] compaction of wood with wood softening treatment first, then pressed under the proportional point will experience non-permanent compression results because it can return to its original thickness or soaking if it gets the influence of moisture or soaking. Furthermore, Dwianto [13] stated that only temporary changes in thickness also occur due to boiling.

Analysis of variance showed that boiling time and interaction between boiling time and compression did not significantly affect the dimensions development, while the compressed time significantly affected the dimensions development. Based on Duncan's comparative test, boiling time of 60 minutes, 90 minutes and 120 minutes was significantly different from the control. Then the pressing time of press time 10 minutes, 20 minutes and 30 minutes was significantly different from the control. The 10 minutes press time was also not significantly different from the 20 minutes press time, but it was significantly different from the 30 minutes press time. The 20 minutes press time was not significantly different from the 30 minutes press time.

3.2.2. Dimension shrinkage. Shrinkage of the dimensions of Terentang wood that was compressed had higher value than Terentang wood which was not compressed. Shrinkage of the dimensions of Terentang wood which was compressed ranged from 6.610% to 11.353%, while the development of the Terentang wood dimension that was not compressed was 5.554%. The test results of shrinkage of Terentang wood dimensions can be seen in figure 7 below.

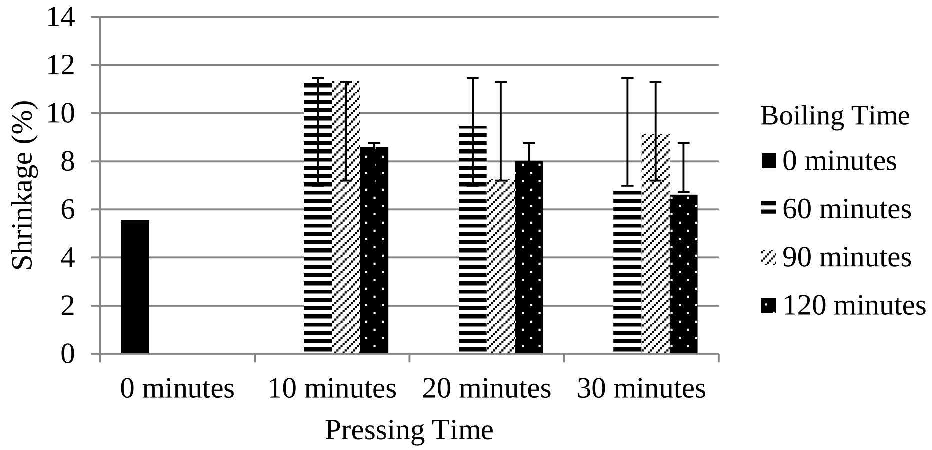

Figure 7. Shrinkage of the dimensions of Terentang wood.

Wood shrinkage is influenced by many factors [14], in this research, the results showed that the longer the boiling and pressing time, the smaller the dimensions of wood produced. Itis because Terentang wood that has been given treatment when pressed and boiled longer has a denser fiber so that changes in the dimensions of the wood remain stable even though the wood has hygroscopic properties. It is in line with the statement of Tomme et al. [15] that the increase in density causes compressed wood cells to tend to flatten, thereby it reduces the volume of cavities, which at the same time reducing the volume of wood while the weight remains so that changes in dimensions are more stable.

Analysis of variance showed that boiling time and interaction between boiling and pressing time did not significantly affect the dimensions development, while the pressing time significantly affected the dimensions development. Based on Duncan's comparative test, boiling time of 60, 90 and 120 minutes was significantly different from the control. Then the pressing time of 10, 20 and 30 minutes was significantly different from the control and the 10 minutes press time was not significantly different from the 20 minutes press time, but significantly different from the 30 minutes press time. The 20 minutes press time was not significantly different from the 30 minutes press time.

4. Conclusions

1. The moisture content and SG of Terentang wood increased, while the development and shrinkage of dimensions did not increase.
2. The boiling time, pressing time and interaction between both have a significant effect on moisture content. The specific weight which has a significant effect is boiling time. While the dimension swelling that have a significant effect is compressed time, Shrinkage dimensions which has a significant effect on press time.

5. Recommendations

1. Terentang wood which was compressed could increase its strong class into a strong class I-II so that it can be used as a substitute for commercial wood for construction raw materials.

2. Subsequent of compression wood can be done by paying attention to the position of the wood based on the axial direction of the tree to see better differences.

6. References

[1] Suhartati, S. Rahmayanti, A. Junaedi & E. Nurrohman. 2012. *Distribution and Growth Requirement of Alternative's Type of Pulp Production in Riau Region* (in Indonesian). Kementerian Kehutanan. Badan Penelitian dan Pengembangan Kehutanan. Jakarta

[2] Panjaitan dan Ardhana. 2010. The prospect of Terentang (*Campnosperma auriculata*) plant in Kalimantan (in Indonesian). *Jurnal Galam*. **4**:71-79

[3] Sulistyono. 2001. *The study of technical engineering, physical, mechanical characteristic and reliability of dented agathis wood* (*Agathisloranthifolia* Salisb) (in Indonesian). Thesis (unpublished). Institut Pertanian Bogor

[4] Arinana and Farah D. 2009. The quality of dented pulai wood (*Alstonia scholaris)* (physical, mechanical and durability characteristic) (in Indonesian). *Jurnal Ilmu dan Teknologi Hasil Hutan* **2**(2): 78-88

[5] Nestri. 2014. The effect of densification to physical and mechanical characteristic of fast-growing teak wood (*Tectona grandis* L.f.) (in Indonesian). Thesis (unpublished). Institut Pertanian Bogor. Bogor

[6] Sailana, G. E., F.H. Usman, A.Yani. 2014. Physical and mechanical characteristic of dented mahang wood (*Macaranga hypoleuca* (reichb.f.et zoll.) m.a) based on steaming time and temperature felts. *Jurnal Hutan lestari*. **2**(2): 317-326

[7] Suroto, E. Setiawati. 2009. *Improvement of low strength wood characteristic with felt technic* (in Indonesian). Peneliti Baristand Industri Banjarbaru

[8] British Standar Institution, 1957. British Standard Methods of Testing Small Clear Specimens of Timber. British Standar Institution. Decorporated by Royal Charter. British Standard House, London. No. 373

[9] Megawati, Fadilah, Eva. 2016. Physical and mechanical characteristic of gerunggang wood (*Cratoxylonarboresescen*Bi.) based on steaming and felt time (in Indonesian). *Jurnal Hutan Lestari*. **4**(2):1663-175

[10] Sulistyono, Naresworo Nugroho, and Surjono Surjokusumo, 2002. *Wood Densification Engineering Technic I* (in Indonesian). Pusat Penelitian dan Pengembangan Hasil Hutan. Bogor

[11] Aribowo, Teguh. 2016. *Physical and durability characteristic of fast-growing dented teak wood* (*Tectonagrandis* L.f.) (in Indonesian). Thesis (unpublished). Institut Pertanian Bogor

[12] Amin, Y and Dwianto, W. 2006. The effect of temperature and water steam pressure to compression wood fixation using close system compression (in Indonesian). *Jurnal Ilmu dan Teknologi Kayu Tropis*. UPT Balai Litbang Biomaterial. Bogor

[13] Dwianto, W. 1999. *Mechanism of Permanent Fixation of Radial Compressive Deformation of Wood by /heat or Steam Treatment.* Doctor Thesis (Unpublished). Kyoto University

[14] Tsoumis G. 1991. *Science and Technology of Wood (Structure, Properties, Utilization)*. New York : Van Nostrand Reinhold

[15] Tomme F. Ph, F. Girrardet, B. Gfellerr, and P. Navi. 1998. *Densified Wood : an Innovative Product With Highly Enhaced Character*