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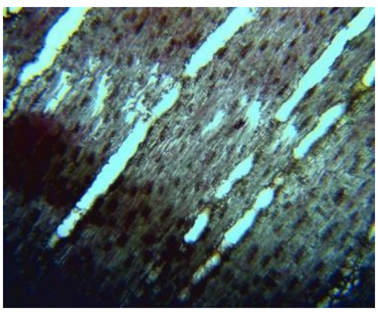
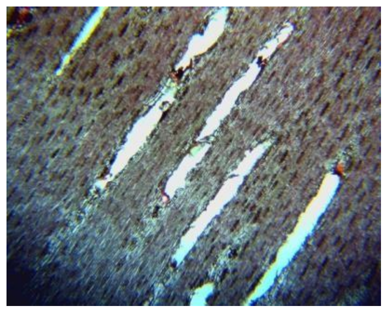
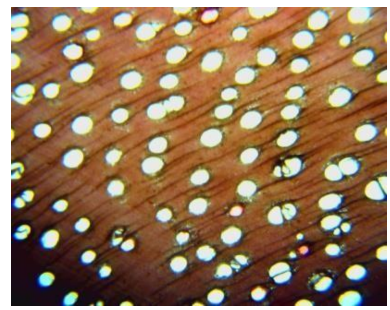
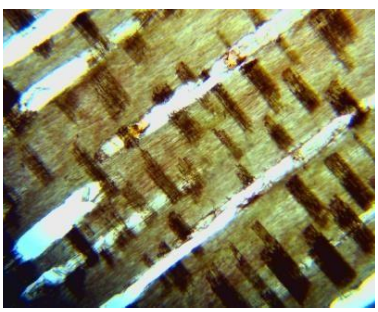
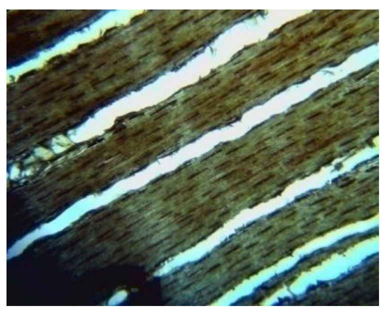
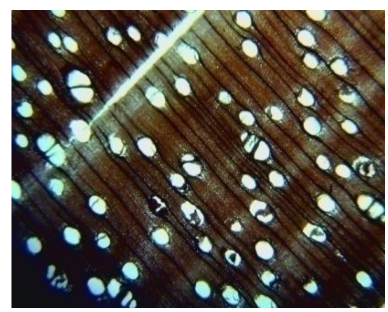

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# WOOD RESEARCH Journal

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# Wood Anatomy and Fibre Quality of the Least Known Timbers Belong to Actinidiaceae from Indonesia

Ratih Damayanti and Listya Mustika Dewi

**Abstract**

Wood anatomy of 417 genera and 86 families belong to the major, minor, and the lesser known timbers of South-East Asia have been studied and described in 3 volumes of PROSEA books. This paper deals with timber species of the least known timbers, which have not been treated in the above mentioned PROSEA books, i.e.: *Saurauia bracteosa*, *S. capitulata*., and *S. nudiflora* from family Actinidiaceae. The objective of this study was to acquire descriptions of their anatomical features and evaluate the quality of their fibres for pulp and paper manufacture. Samples were provided by Xylarium Bogoriense, which were collected from various forest areas in Indonesia. Microscopic features observed comprise all features those listed by IAWA Committee in 1989. Fibre quality was determined based on their dimension and evaluated according to quality classification developed by FPRDC Bogor. The results indicate that identification of timber up to genera level is possible. Fibres of *Saurauia* spp. fall into quality class I, which means good for pulp and paper. The descriptions of anatomical features were presented. Sauraria have bright color, light yellow to light brown, fine texture, light, smooth to rather rough surface, and make it suitable to substitute ramin (*Gonystylus* spp.)

**Keywords:** wood anatomy, fibre quality, the least known timbers, Saurauia, Actinidiaceae.

## Introduction

Indonesian forest is one the richest biodiversity tropical rain forests in the world which has unique characteristics. Some reports stated that Indonesian forest has about 30,000 floras and 4,000 of them are classified as forest tree species (Sastrosumarto 1987). Among 4,000 tree species, 400 species were known as important species, and 259 species of them were known as commercial species. Those 259 species have been classified into 120 groups of commercial tree species.

Wood anatomy of 417 genera and 86 families belong to the major, minor, and the lesser known timbers of South-East Asia have been studied and described in 3 volumes of PROSEA Books (Soerianegara and Lemmens 1994; Lemmens *et al.* 1995; Sosef *et al.* 1998). Indonesian Xylarium Bogoriense 1915 has approximately 3,667 wood species collection. For this time, there are about 800 species from 251 genera of 77 families where the properties and anatomical structure have never been studied. Those later species are named as *The Least Known Timber*, to continue the Plant Resource of South-East Asia 5:1-3.

This paper deals with three timber species of *the least known timber*, which have not been treated in the above mentioned PROSEA books, i.e.: *Saurauia bracteosa*, *S. capitulata*, and *S. nudiflora* from Family Actinidiaceae. The objective of this study was to acquire descriptions of their anatomical features and evaluate the quality of fibres for pulp and paper manufacturing.

## Materials and Methods

The least known timber belongs to Actiniadeae was determined and collected from Xylarium Bogoriense 1915. The profiles of these species accordance with their scientific name, collection number, origin, and durability class as well as strength class based on Oey (1964) are elaborated in Table 1.

Observation on anatomical structures consist of macroscopic (general) and microscopic characteristics. Macroscopic features were observed on the planed surface of the sample as suggested by Mandang and Pandit (2002) including color, figure, texture, slope of grain, hardness, luster, odor and surface impression.

Microscopic characteristics were examined in the sectioned samples. As many as three block representing transverse, radial, and tangential surfaces are prepared from heartwood and used for examination of anatomical features. Wood blocks were at first air-dried and then soaked in distilled water for about one week. After being saturated, the samples were then transferred into a container containing a softening solution of ethanol-glycerin 1:1 and further kept for about one week before being sectioned into 15~25 μ thin slices. The good slices were chosen and washed in stages using ethanol with concentrations consecutively 30%, 50%, 70%, and ultimately absolute ethanol (96%). The slices were cleared by soaking them in xylene and toluene. The last was to mount the slices on the object glass using entellan (Sass 1961).

The characteristics were observed with respect to the anatomical features listed on IAWA Committee List for Hardwood Identification (Wheeler *et al*. 1989). The quantitative data in this study consisted of tangential diameter of vessels (25-time measurements), frequency of vessels per mm square, frequency of rays per mm (10-time over 10 different areas), and heights of rays (25 times), and then calculating the average (Krisdianto and Damayanti 2007).

The quantitative data of fibers dimension (25-time measurements), diameter and thickness of wall cells (15-time measurements, respectively) and vessel length (25-time measurements) were measured from the sectioned and macerated samples. In this regard, the wood samples were macerated according to the method of Tesoro (1989). The sample materials were heated slowly at 40~60ºC in the mixture of concentrated nitric acid and hydrogen peroxide at a ratio of 1:1. The heating process took about 12 hours to produce adequately macerated material or a satisfactory separation of cells for further dimensional measurement.

The separated fiber cells were washed by water to rid the cells completely of residual acid and hydrogen peroxide and then were colored by safranin. To examine their dimensions, the cells were placed on the object glass; ethanol-glycerin was then added, and the cells were evenly spread using a coarse needle before closing the object glass with cover glass. The qualification of fiber for pulp and paper was based on the criteria of Rachman and Siagian (1976), through the determination of fiber dimension and its derivative values.

Table 1. Description of collection number, name, durability class, and strength class of eight least known timbers belong to Actinidiaceae from Indonesia.

| Species | Collection Number | Specific Gravity* | Strength Class* | Durability Class* | Origin |
|---|---|---|---|---|---|
| *Saurauia bracteosa* DC. | 13075 | - | - | - | Malang, East Java |
| *Saurauia capitulata* Smith | 26261 | 0.40 | III | V | Maluku |
| *Saurauia nudiflora* DC. | 2913 | 0.43 | III | V | Rejang, Bengkulu (Sumatra) |

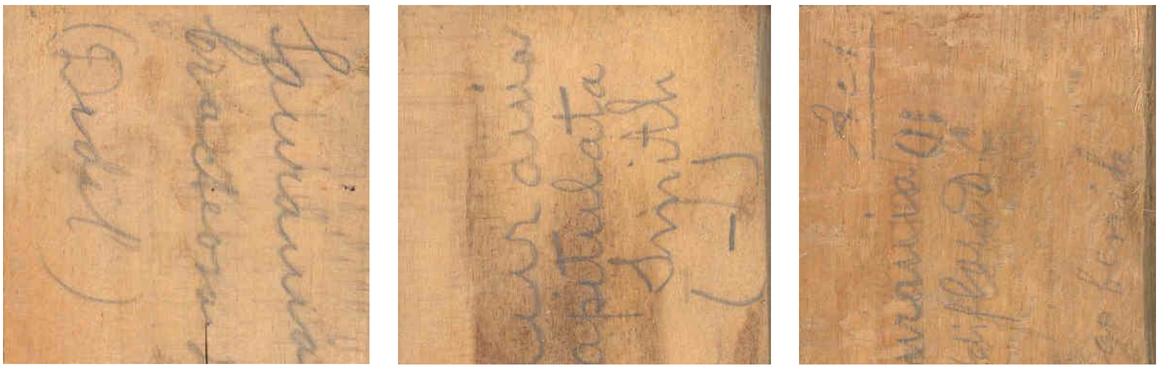
*Source: Oey (1964)

## Results and Discussion

### Anatomical Properties

The description about Actinidiaceae has been reported by Watson and Dallwitz (1992). According to them, Actinidiaceae or the Chinese Gooseberry, is a small family of plants. It includes three genera and has about 360 species. Saurauia has 300 species, and it is the largest genus in this family. They are temperate and subtropical woody vines, shrubs and trees, native to Asia (Actinidia or kiwifruit, Clematoclethra, Saurauia) and Central America and South America (Saurauia only). Although now confined to Asia and tropical Central and South America, there is evidence that in the past this family had a wider distribution.

Anatomical properties of the least known timbers of Actinidiaceae from Indonesia and its comparison with another observer's result are described in Table 2. The figures of macroscopic and microscopic anatomical sructures of every species are presented in Fig. 1~4.



*Saurauia bracteosa* *S. capitulate* *S. nudiflora*

Figure 1. Longitudinal surface of *Saurauia bracteosa, S. capitulata and S. nudiflora*, x 1.

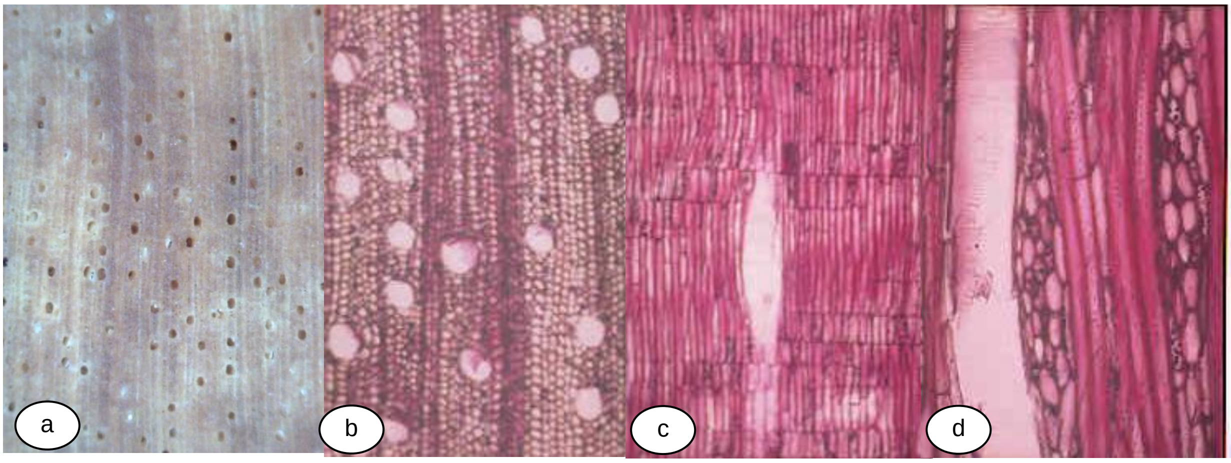



Figure 2. *Saurauia bracteosa* (a) transverse surface (macroscopic), x10; (b) transverse section (microscopic), x40; (c) radial section, x40; and (d) tangential section, x100.

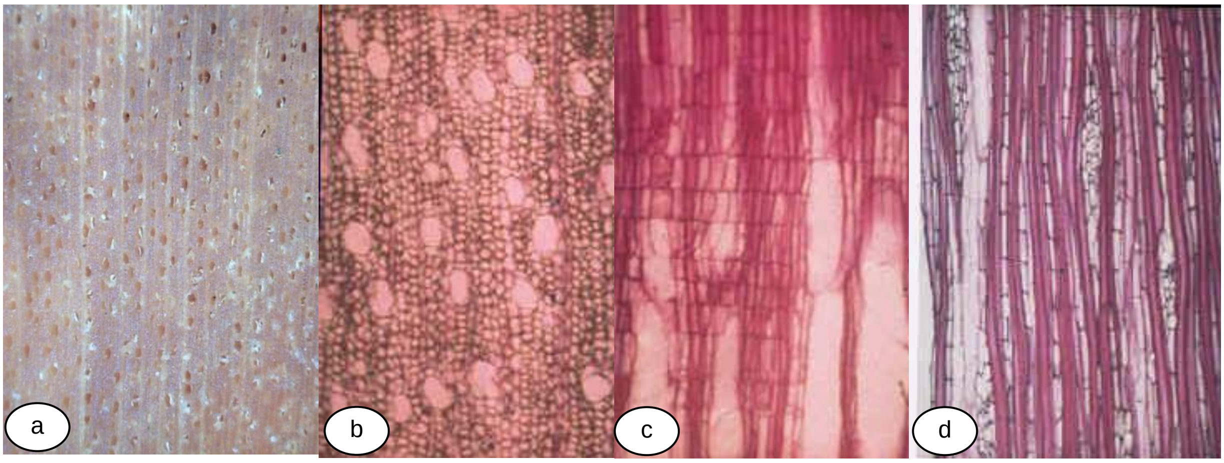



Figure 3. *Saurauia capitulata* (a) transverse surface (macroscopic), x10; (b) transverse section (microscopic), x40; (c) radial section, x100; and (d) tangential section, x40.

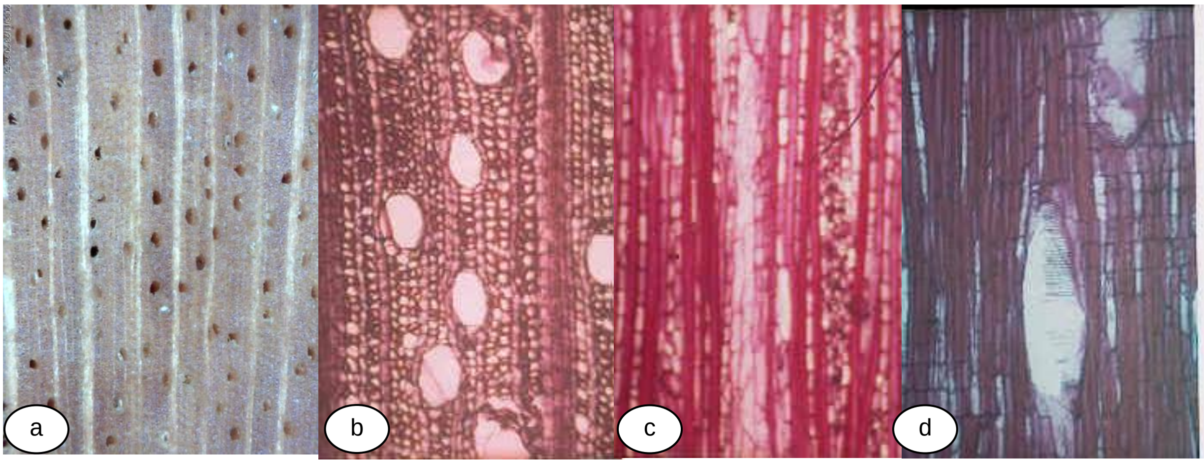



Figure 4. *Saurauia nudiflora* (a) transverse surface (macroscopic), x10; (b) transverse section (microscopic), x40; (c) radial section, x40; and (d) tangential section, x40.

Table 2. Description of anatomical characteristics of least known timbers of Sauraria.

| Species | Origin | General Characters | Anatomical Characteristics (Wheeler *et al*. 1989) | Comparison with Other Observers | |
|---|---|---|---|---|---|
| | | | | Wilkins (1987)* | Watson and Dalwitz (2009) |
| *Saurauia bracteosa* DC. (Coll. Number: 13075) | Malang, East Java | Color: light-brown.<br>Figure: plain.<br>Texture: fine.<br>Grain: interlock.<br>Wood is light; moderately soft to hard. Its surface is lusterless and smooth to moderately rough. No special odor. | Growth ring: 2<br>Vessel: 5, 9, 12, 14, 17, 18, 21, 29, 30, 31, 32, 33.<br>Axial parenchyma: 76, 92.<br>Rays parenchyma: 97, 98, 107, 109.<br>Fibres: 62, 63.<br>Mineral inclusion: -<br>Others: 110. | | Cork cambium present; initially deep-seated, or superficial. Nodes unilacunar (usually), or tri-lacunar. Secondary thickening developing from a conventional cambial ring. Xylem with tracheids; with vessels. Vessel end-walls in tangential direction; simple, or scalariform and simple. Wood parenchyma apotracheal. Pith with diaphragms. |
| *Saurauia capitulata* Smith. (Coll. Number: 26261) | Hollandia, Molluken | Color: cream (light-yellow).<br>Figure: plain.<br>Texture: very fine.<br>Grain: straight.<br>Wood is light and soft. Its surface is lusterless and smooth. No special odor. | Growth ring: 2<br>Vessel: 5, 12, 14, 18, 19, 21, 25, 30, 31, 41, 47.<br>Axial parenchyma: 76, 78, 93.<br>Rays parenchyma: 97, 108.<br>Fibres: 62, 63, 66, 69.<br>Mineral inclusion: -<br>Others: 110. | | |
| *Saurauia nudiflora* DC. (Coll. Number: 2913) | Rejang, Bengkoelen (Sumatera) | Color: light-brown.<br>Figure: plain.<br>Texture: moderately coarse.<br>Grain: straight, moderately in tangential direction to interlock.<br>Wood is light and rather soft. Its surface is lusterless and smooth. No special odor. | Growth ring: 2<br>Vessel: 5, 12, 14, 17, 19, 30, 31, 41, 47, 60.<br>Axial parenchyma: 78, 84, 92.<br>Rays parenchyma: 97, 98, 107.<br>Fibres: 63, 66, 69.<br>Mineral inclusion: 149 (in axial parenchyma), 150 (separated observed, needle shape, ± 6 in amount).<br>Others: 110. | 1, 7, 8, 9, 11, 18, 21, 25, 28, 30, 33, 35, 36, 45, 46, 64, 75. | |

* Computer key for the identification of the word commercial timbers in OXFORD List.

From Table 3, it can be seen that there are some differences between this study and another study by Wilkins (1987). It might be caused by different site conditions where they were grown which is tropical and temperate forest. The difference was predominantly shown by the presence of distinct growth ring in wood samples studied by Wilkins (1987). It is commonly understood that most of tropical wood species has indistinct growth rings due to even climate conditions along the annual growth period.

**Fiber Quality**

Measurements and calculations of wood fiber dimensions are presented in Table 3.

Table 3. Average value of fiber wood dimension.

| Collection Number | Timber Species | Length (L) (µm) | Diameter (d ) (µm) | Lumen (e) (µm) | Wall thickness (w) (µm) |
|---|---|---|---|---|---|
| 13075 | *Saurauia bracteosa* | 3078.22±399,15 | 54.54±5,32 | 48.26±5,15 | 3.14±0,46 |
| 26261 | *Saurauia capitulata* | 2986.69±289.96 | 59.50±8.97 | 53.25±8.14 | 3.13±0.74 |
| 2913 | *Saurauia nudiflora* | 3396.15±453.17 | 56.66±7.71 | 50.35±7.04 | 3.15±0.54 |

Table 4. Fiber dimension derivative value and fiber class quality for pulp and paper.

| Wood Species | Fiber lenght (µm) | Runkel ratio | Felting point | Flexibility ratio | Coeficient of rigidity | Muhlsteph ratio | Score total | Class Quality |
|---|---|---|---|---|---|---|---|---|
| *Saurauia bracteosa (*13075) | 3078.22 | 0.13 | 56.44 | 0.88 | 0.01 | 21.70 | | |
| Grade | 100 | 100 | 50 | 100 | 100 | 100 | 550 | I |
| *Saurauia capitulata* (26261) | 2986.69 | 0.12 | 50.20 | 0.89 | 0.05 | 19.91 | | |
| Grade | 100 | 100 | 50 | 100 | 100 | 100 | 550 | I |
| *Saurauia nudiflora* (2913) | 3396.15 | 0.13 | 59.94 | 0.89 | 0.06 | 21.03 | | |
| Grade | 100 | 100 | 50 | 100 | 100 | 100 | 550 | I |

Remarks (Rahman and Siagian, 1976):

1) Runkel Ratio = 2w/l — L = Fiber length
2) Felting point = L/d — d = Fiber diameter
3) Flexibilty ratio = l/d — l = Lumen diameter
4) Coeficient of rigidity = w/d — w = Wall thickness
5) Muhlstep ratio = $\frac{(d^2-l^2)}{d^2}$ x 100 %

Fiber dimension derivative value and class quality of the fiber are presented in Table 4. Based on Table 4, the fiber quality as a proposed material of pulp and paper of *Sauraria* spp. fall into class I. According to Rachman and Siagian (1976), the wood characteristics of class I cover moderate to low density wood species (strength class IV/V) with extremely thin wall and wide lumen. Fibers collapse completely during pulp sheet forming; flattening and felting characteristics are high, resulting in high tear, burst and tensile strength of the corresponding pulp.

From the result of fiber quality and their bright color, the entire of species have good potency to be used as raw material of pulp and paper, but the low value of their specific gravity (less than 0.5) can be a weakness that must be considered because they will produce small recovery. Moreover, to obtain more reliable results to support basic classification in determining the quality of pulp and paper processing, future research should also examine the chemical components of the wood such as cellulose, lignin, pentosan, extractives and ash contents. The presence of mineral inclusion of *Saurauia nudiflora* might affect refining process during the pulping process.

**Evaluation of Possible Uses**

In agreement with Oey (1964), without take any consideration into other properties; in wood construction, strength and durability class of the timber have main effects for utilization. The strength class of all specimen are medium (range from II to IV, majoring in III), while durability class are very low, so the species barely suitable for temporary and light construction, except there are preservation treatment.

Literature on utilization of the least known timbers is very limited. Sauraria has good appearance (bright color- light yellow to light brown, fine texture, light, smooth to rather rough surface) make it suitable for ramin (*Gonistylus* sp.) substitution.

Utilization based on anatomical properties for every timber need more observation. By sufficient knowledge in basic properties of wood as raw material, it is possible to make an appropriate product to increase the economic value of the least known timbers.

## Conclusions

This study has examined deeply the anatomical properties of the least known timbers from family Actinidiaceae, which have not been treated in PROSEA books: *Saurauia bracteosa*, *S. capitulata*, and *S. nudiflora*. Fibres of *Saurauia* spp. fall into quality class I, which means good for pulp and paper. The good appearance ofSaurauria is suitable to substitute ramin (*Gonystylus* sp.). Exploration on the properties of the least known timber in Indonesia should be continued intensively. Based on the economical aspect, timbers from this group are potential to be developed.

## Acknowledgements

The authors would like to appreciate and thank Dra. Sri Rulliaty, M.Sc. (RIP) for the support of this study, Mr. Usep Sudardji and Ms. Tutiana for their meticulous help in preparing the sectioned and macerated slides, and in measuring the dimensions of wood fibers.

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# The Effect of Traditional Fumigation on Physical, Mechanical and Anatomical Properties of Wooden Handicraft in West Kalimantan

Farah Diba and Lolyta Sisillia

**Abstract**

West Kalimantan wooden craft is internationally well known and its export is increasing. Currently, high durability and attractive color of wood material such as belian (*Eusideroxylon zwageri* Teysm & Binnend) is rarely available, then alternatively mangium (*Acacia mangium* Willd.) and laban wood (*Vitex pubescens* Vahl.) are used for handicraft. Fumigation is one possible way to improve wood service life and color shades. This paper determines the impact of traditional fumigation on wood raw material on physical, mechanical and anatomical properties. The timber fumigation technique was conducted for one week, with curing time from early morning until late afternoon. After treatment, the physical, mechanical and anatomical properties of wood were evaluated. The different of color before and after treatment was measured by image processing scanner Canon P 145. Physical and mechanical properties refer to the British standard method. Result shows that fumigation improves the quality of wood, especially on color of wood. The wood became dark and more shining. It's good for the handicraft materials. The quality of wood on moisture content value, both on mangium and laban wood was increased with average 30-50%. The average value of wood density of mangium wood after treatment with fumigation was 0.52, meanwhile laban wood was 0.55. The average value of radial shrinkage of mangium wood after fumigation treatment was 3.96% and tangential shrinkage was 6.34%. The average value of radial shrinkage of laban wood after fumigation was 6.43% and tangential shrinkage was 6.08%. The average value of hardness of mangium wood after fumigation treatment was 470.13 kg/cm$^2$ and laban wood was 625.46 kg/cm$^2$. The Fumigated wood color was darker and more attractive for decorative and craft products than non-fumigated wood. In general, this method could be used to preserve wood and to increase the physical performance of wood as raw material for handicraft.

**Keywords**: *Acacia mangium*, fumigation, *Vitex pubescens,* West Kalimantan, wood craft.

## Introduction

Wood craft industry in West Kalimantan Province currently faces low raw material wood supply which has an attractive color and pattern as well as high in wood durability. Raw material is one of the elements that determine the quality of product so that the high quality wooden handicraft products indispensable quality raw material which is strong, durable, attractive in color and pattern (Khan *et al*. 2018). In addition, the price of high durability grade wood is now very expensive, then it is not economically in terms of raw material usage.

West Kalimantan craftsmen knows belian wood (*Eusideroxylon zwageri* Teysm & Binnend) as high-grade, durable, strong and decorative wood. However, the supply of belian wood is now diminishing. Alternatively, the craftsmen's using alternative species such as mangium (*Acacia mangium* Willd.) and laban wood (*Vitex pubescens* Vahl.) which are easily obtained, but lower durability grade than Belian wood (Abdurrohim *et al*. 2004).

Laban and mangium wood from land clearing forest are processed into wood carving handicraft items such as lawn chairs, statues, shields, and wall hangings. Mangium wood is classified as strong class II and class II-III durability, and laban wood is classified as strong class II and class I-II durable (Oey 1964; PIKA 1981). The average of mangium wood density of natural stand is about 0.6.. Arsad (2011) stated mangium heartwood was slightly brown colored, hard, strong, and durable in well-ventilated areas, though the wood is not resistant in contact with the ground Meanwhile laban wood also susceptible on fungi and termites attack (Oramahi *et al*. 2011). Fumigation is an alternative method for improving wood quality. Fumigation is one way to improve wood service life prior to further process (Duljapar 1996). Fogging treatment also aims to increase the value of the decorative wood. Suranto (2002) stated traditionally fumigation techniques by craftsmen is an alternative for wood preservation without chemical and attempt to preserve the natural wood, with curing time of treatment approximately a week.

Currently, timber fumigation is not widely conducted by timber industries to preserve wood. It is caused by the fact that there is limited study on the effects of fumigation into wood properties: physical, mechanical and anatomical. Though the process of curing could increase the service life of the wood product (Bower *et al*. 2009) and increase the durability of wood product against organisms and microbial destroyer (Abolagba and Igbinevbo 2010). The quality improvement of wooden handicraft products with traditional fumigation techniques should be supported by durability testing of wood against wood destroying organisms, especially termites.

This paper determines the impact of traditional fumigation on mangium wood and laban wood as materials for wood handicraft on physical, mechanical and anatomical properties of the woods.

## Materials and Methods

### Sample Preparation

Two wood species: mangium (*Accacia mangium* Willd.) and laban (*Vitex pubescens* Vahl.) were collected from wood craftsmen who lives in Budi Utomo street, Northern District of Pontianak City, West Kalimantann Indonesia. Wood raw material measuring length 100 cm, width 30 cm and .thickness 10 cm. Wood samples were grouped into two: fumigation and control (non-fumigation) with three replicates in a state of air dry. The average value of air dry density of mangium wood is 0.50 and laban wood is 0.51. The sample size for testing physical and mechanical properties refer to British Standard No. 373 (1957), consist of sample for moisture content and density with size 2 cm x 2 cm x 2 cm, dimension stability of 2 cm x 2 cm x 4 cm, mechanical properties (hardness) (of 2 cm x 2 cm x 6 cm and anatomical properties of 2 cm x 2 cm x 2 cm.

### Sample Testing

Anatomical properties were evaluated based on macroscopic and microscopic structures. Sample for anatomical test was three replication. The macroscopic properties of wood anatomy were observed using loupe with 12-15 times magnification and wood color measurer. Touch impression was determined by touching the surface of wood which was conducted by three people (Arinana and Diba 2009).

### Determination the Color of Wood

Wood color was measured using image processing scanner of Canon P 145 which connected to the MacBook Pro as a data storage and processed with Adobe Photoshop CS4 software that generates the value of L*, a* and b* which refers to Kjallstrand and Petersson (2001). Analysis of wood color based on color difference ($\Delta E$), and data then compared to Table 1 to determine the effect of color differences. Color difference ($\Delta E$) is calculated based on the CIELAB system (Christie 2007) with the formula:

$$\Delta E = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2}$$

Where :

$\Delta E$ = Color differences

$\Delta L^*$ = Lightness differences (L* before and after staining)

$\Delta a^*$ = Red to green differences (a* before and after staining)

$\Delta b^*$ = Yellow to blue differences (b* before and after staining)

Table 1. The effect of color differences

| Different Color | Effect |
|---|---|
| < 0.2 | Not visible |
| 0.2 – 1.0 | Very small |
| 1.0 – 3.0 | Small |
| 3.0 – 6.0 | Moderate |
| > 6.0 | Large |

Source: (Christie 2007)

## Results and Discussion

### Physical Properties of Wood

**Moisture content.** The average value of moisture content of untreated mangium wood was 15.29% and laban wood was 19.1%. Meanwhile the average value of moisture content of fumigated mangium wood was 9.85%, and laban wood was 5.88%. Moisture content of fumigated laban wood is less than mangium wood. Analysis of variance shows that fumigation treatment is significantly affect the value of mangium and laban wood moisture content, which means the moisture content of treated wood and untreated is significantly different. Analysis of variance of the interaction between fumigation treatment and wood species on moisture content resulted in very significant effect, which meansthe fumigation treatment has a different effect on moisture content value to mangium and laban wood. Fumigation treatment made the moisture content of mangium and laban wood decrease and it is good condition for wood as raw material of handicraft. The less moisture content made wood easy to crafting and more durable to wood destroying organims (Suranto 2002). The wood species

The fumigation treatment provides moisture content differences of treated and untreated wood. It is shown that moisture content of untreated mangium wood was about 15.29% and the treated of mangium wood was only 9.85%. Similarly, moisture content of untreated laban wood was about 19.1% and treated laban wood was about 5.88%. The moisture content values of treated and untreated mangium and laban wood are presented in Fig. 1.

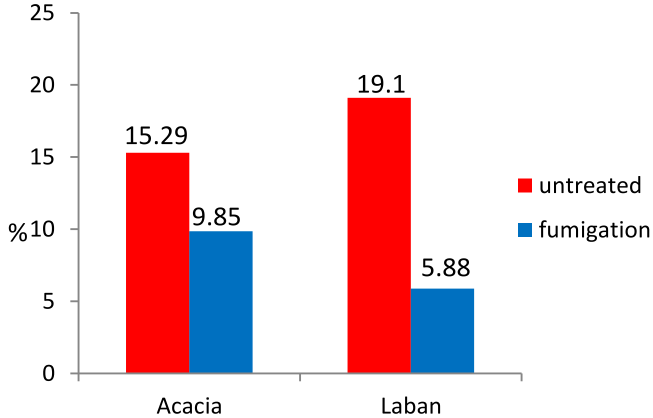



Figure 1. The moisture content of mangium and laban wood

Fig. 1 shows the average value of mangium and laban moisture content and Laban. Moisture content of fumigated wood are lower than untreated wood. Lower moisture content is mainly caused by lost of free water in cell cavities and less bound water in the cell wall. Fumigation process achieves its target in minimizing the moisture content of mangium and laban wood. Fumigation treatment greatly affects the value of the moisture content of mangium and laban wood. Rofii and Prayitno (2012) stated that the same phenomena is shown in jackfruit wood where moisture content was decreasing after steaming.

Pasaribu and Sisillia (2012) also reported that the change rate of teak moisture content increased inline with heat treatment. Moisture content reduction of fumigated wood was due to the water evaporation from the wood cells. Water evaporation influences the air temperature and humidity during curing process (Martinez *et al*. 2007). Amin and Dwianto (2006) also mentioned that the heat would urge the moisture out from the wood. High temperature damages the water molecules in the wood cells during high temperature treatment. In this condition, the heat causes damage to the H bonds between molecules within the matrix of hemicellulose-lignin.

Todd (2003) stated that moisture content of wood that had been fumigated reflects the percentage weight of water relative to the total weight of wood. Fumigation process generates heat that dries the wood and evaporate water from the wood cells. The amount of moisture in air dried mangium and laban is in the range of moisture content of air dry wood for Indonesian climate which is about 12-20% (Praptoyo 2010). Laban wood moisture content obtained from craftsmen is still above the SNI standard (SNI.01-0608-89) which states that the requirement of raw materials for furniture and wood crafts are 15% maximum (dry air). Hence, fumigated wood meets the standard in term of moisture content. Fumigation made the moisture content of wood decrease. When the process of wood fumigation, heat and smoke during the process made the wood dry and decrease the water inside the wood. Low moisture content levels will increase the resistance of wood against wood destroying organisms such as fungi and termites (Nandika et al 2015)

**Wood density.** The average of wood density of untreated mangium wood and treated wood was 0.62 and 0.52 respectively. Wood density of untreated and treated laban wood was 0.58 and 0.55 respectively. The treated mangium wood density were less than treated laban wood. Based on the analysis of variance, timber fumigation did not significantly affect the density of mangium and laban wood. The density value of untreated mangium wood and laban wood were relatively higher than the density of fumigation mangium and laban wood. The traditional fumigation methods was conducted in open area and the smoke during the process has widespread around the wood. The temperature inside the place of fumigation was unstable and made the effect to wood. Traditional fumigation treatment makes the density of wood low. According to Tsoumis (1991) wood density is influences by the cell size, thickness of the cell wall and the relationship between the number of cells varying to the size and thickness of the wall.

Palm *et al*. (2011) stated that fumigation is the penetration of volatile compounds (volatile matter) produced from burning wood and create products with specific odour derived from wood combustion. Fumigation generally used in food preservation processes such as fish, beef or other food processed products. The value of density mangium wood from fumigation treatment results are relatively similar with those reported by Hadjib *et al*. (2007). Density value of mangium wood before treatment was 0.62 and after fumigation was decreased into 0.52. Laban wood density before treatment was 0.58 and after fumigation was decreased into 0.55. Results show in general fumigation treatment decreased wood density. It is analogous to the relationship between the moisture content and density of the wood reported by Haygreen and Bowyer (1996), where wood density tends to decrease with increasing of moisture content.

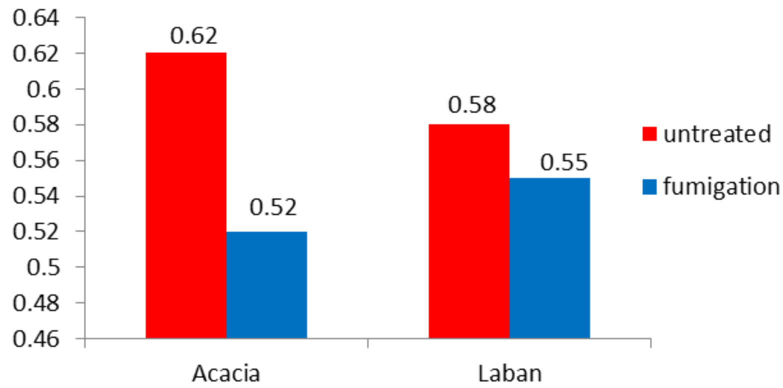



Figure 2. Density of mangium and laban wood.

The average value of the wood density of treated and untreated mangium and laban wood is presented in Fig. 2. Fig. 2 shows based on its density, mangium and laban wood are grouped into medium density wood. Measurement results of the mangium and laban wood density are classified as strong class II-III based on Regulation Timber Construction Indonesia (PKKI). Based on physical properties of moisture content and density, the treated mangium and laban wood could be used for craft materials and furniture.

**Radial and tangential shrinkage.** Wood shrinkage observed in this study was radial and tangential shrinkage. The average value of radial shrinkage of untreated and treated mangium wood was 3.58% and 3.96%, and 5.96% and 6.34% in tangential shrinkage. The average value of radial shrinkage of untreated and treated laban wood was 4.98 and 6.43% respectively, while in the tangential direction was 4.74% and 6.08% respectively (Fig. 3). Based on the analysis of variance for the average value of radial direction shrinkage of wood, timber fumigation did not significantly affect shrinkage in radial direction, whereas the wood species and their interaction was not significantly different. High significant difference test results is recorded in radial shrinkage of fumigated wood. Results of analysis of variance shows tangential shrinkage, fumigation treatments and wood species had no significant effect.

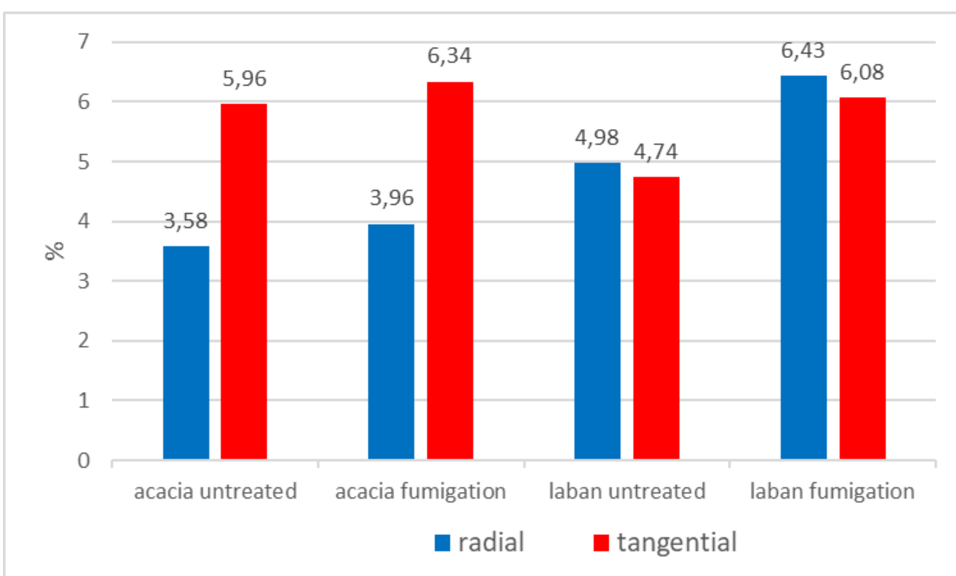



Figure 3. Radial and tangential shrinkage of mangium wood and laban wood.

The average value of mangium wood shrinkage in the radial direction is smaller than laban wood, both on treated and untreated wood. Vice versa the average value, of mangium wood shrinkage in tangential direction was higher than laban wood. Basri *et al*. (2015) stated that mangium wood after grirdling treatment has a radial shrinkage from green to oven-dry condition (%) was 2.78% and tangential shrinkage from green to oven-dry condition was 7.87%. Compare to our research the radial shrinkage of treated mangium wood was 3.96% and tangential shrinkage was 6.34% Fig. 3 shows that in general tangential shrinkage value is higher than those of radial direction. According to Dumanauw (1990), more wood shrink in the direction of a growing circle (tangential), and reduced in the transverse direction circle grew and very little shrink in the direction along the fiber (longitudinal). The differences are due to tangential and radial directions perpendicular to the fiber orientation. Fiber elongated shape in the direction of the fingers and thought that all cells are the longitudinal direction has a shrinkage which is very small in the direction of its length, therefore, the fingers will resist shrinkage radial elements longitudinally.

**Mechanical Properties**

**Hardness of wood.** Wood hardness is one of important mechanical properties on determination ability of wood to withstand the style up a notch or indentation or scraping (abrasion). The average value of hardness of treated mangium wood with fumigation was lower than untreated mangium wood, which respectively value 470.13 kg/cm$^2$ and 687.1 kg/cm$^2$. Similarly, the hardness of untreated laban wood was higher than treated wood with value of 712.2 kg/cm$^2$ and 625.46 kg/cm$^2$. Hardness value of mangium wood and laban wood is presented in Fig. 4.

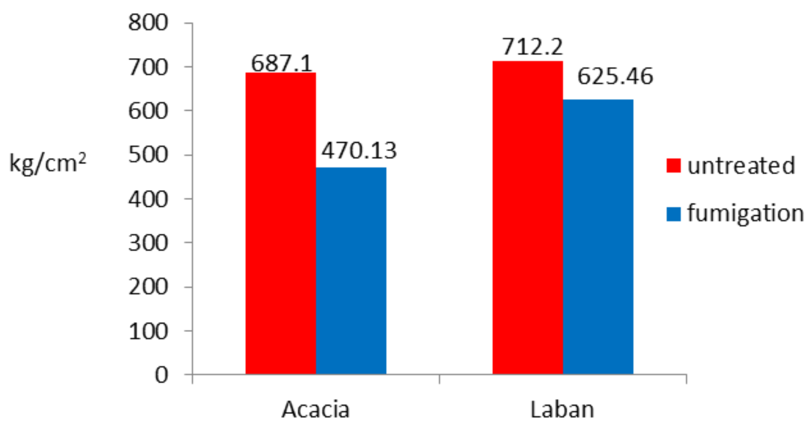



Figure 4. Hardness value of mangium and laban wood.

Based on the analysis of variance, timber fumigation treatment did not significantly affect the hardness value of mangium and laban wood. This is evidenced by the average value of the hardness smoked wood lower than untreated, either on mangium and laban wood. Mangium wood hardness value in this study is higher than the results of the study of Hadjib *et al*. (2007) which hardness value of 384.5-443.0 kg/cm$^2$. Laban wood hardness value is much lower compared to the results of research of Widiati and Susanto (2005) with an average value of 102,8 kg/cm$^2$.

Wood density affect the properties of hygroscopicity, shrinkage, strength, acoustic and electrical properties as well as other properties associated with subsequent woodworking (Tsoumis 1991). From the results of tests performed showed hardness values of treated mangium and laban wood was lower than untreated wood. d. This is in line with the statement that the wood heat treatment to improve the durability, lower hygroscopicity and improve dimensional stability of the wood, in addition, it can decrease the strength and hardness of wood (Boonstra *et al*. 2007).

**Wood Anatomy Properties**

**Macroscopic wood properties.** The macroscopic properties of mangium and laban wood data was recorded from macro observation with magnifying glass of 10-15X. This data includes color, direction of fibers, surface gloss, smell, texture and touch impression. The rough nature of such wood fiber direction, color, odor, texture, impression felt, and gloss is obtained from observations of various surfaces (Sarajar 1982 as cited by Wahyudi 2013). Wood color is caused by the presence of certain pigments. Wood texture refers to the feel of a piece of wood. It can be smooth or rough,. Results of the study are presented in Table 2.

Table 2. Macroscopic of mangium and laban wood.

| Wood | Treatment | Fiber direction | Color | Surface texture | Odor | Touch impression |
|---|---|---|---|---|---|---|
| Mangium | untreatment | straight | cream/beige | shiny | odorless | smooth, slippery |
| | fumigation | straight | black brown | shiny | smoke smell | sheen slick |
| Laban | untreatment | straight and blend | White brownies | not shiny | odorless | sheen |
| | fumigation | straight and blend | black brown | shiny | smoke smell | sheen slick |


Laban wood untreated Fumigated Laban wood Mangium wood untreated Fumigated Mangium wood

Figure 5. Color of Mangium and Laban wood before and after fumigation.

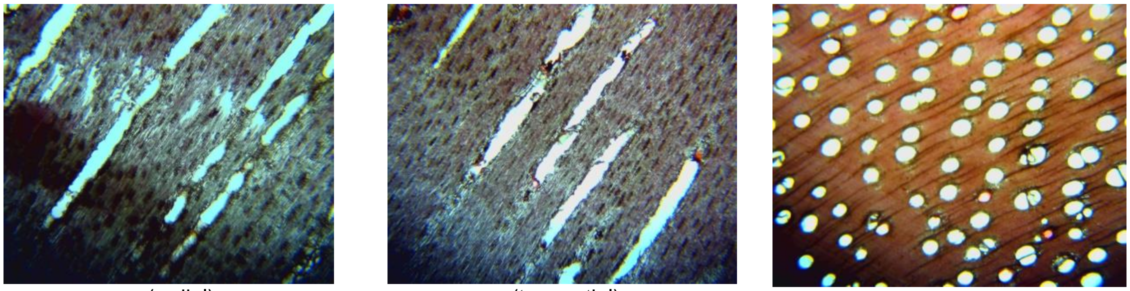
Fumigation of wood produced different colors from the original color, and the wood is darker. Untreated mangium wood color was light brown while treated fumigation wood color was black brown. This is due to the high temperature during fumigation. The untreated mangium and laban wood color was brighter than the color of fumigation wood. Visual color and surfaces of mangium and laban wood for both treatment are presented in Fig. 5.

The effect of different colors (ΔE) at untreated mangium and laban wood and treated mangium and laban wood a row by 14.46 and 32.29. Under the influence of differences in the color table (Hunter Lab 2008), the color difference >6.0 indicates that the temperature during the fumigation was a considerable influence on the staining wood. The value of color difference (ΔE) of laban wood is greater than mangium wood. This is evident from the test sample of laban in Fig. 5, where the wood is not pure white after fumigation and turned into a dark brown slightly black. Darker colors provide more decorative timber and preferably by craftsmen. Mostly the craftsman made a pattern of wood crafting, then fumigated the wood. This material will increase the value of wood handicraft. According to Inoue *et al*. (1992) as cited by Sulistyono and Surjokusumo (2001) fumigated wood provides an attractive color appearance, in which the color changed to a darker after high temperature during the process.

Fumigated mangium and laban wood has the impression of more delicate touch and slippery than untreated wood. This is due to the narrowing of pores or voids wood cells so that the surface becomes smooth compared with those of larger pores or voids (Bowyer *et al*. 2003). The impression of a smooth touch will facilitate the further process for crafting of the wood carving. Mangium and laban wood curing process results causes mangium wood surfaces become more shiny than untreated wood. The fumigation wood when touched feels more slippery, smooth and textured surfaces as the waxy layer provide wood is lighter in color than untreated wood. This impression is influenced by the presence of extractive substances. This character is very interesting, because of the color, pattern and surface gloss and smoothness smoked wood decorative value and will provide added value to be used as interior components.

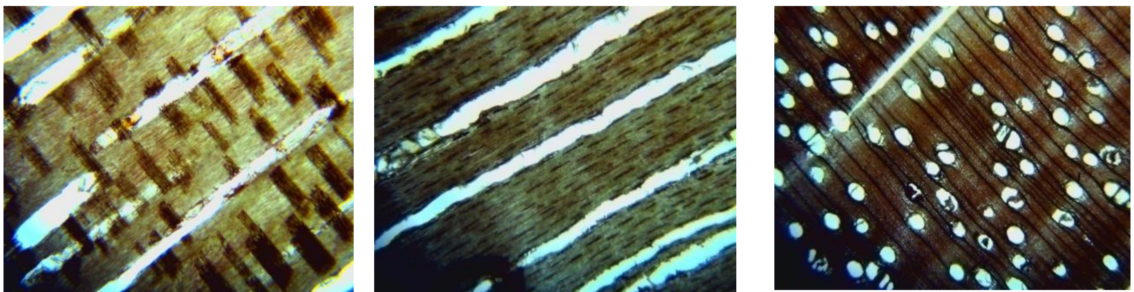
Fumigation treatment does not affect the direction of the wood fibers. In general, Mangium wood which treated and untreated showed a straight grain direction. Fiber direction associated with longitudinal orientation of the cells making up the dominant timber to the axis of the rod. Fiber direction is said to be straight because of the orientation of the mangium wood cell is parallel to the axis of the rod.

**Microscopis wood properties.** Observations wood fiber radial direction, radial, tangential using a microscope with a magnification of 30X. There is a relationship change in the anatomical structure of the wood with fumigation treatment. Fumigation treatment of mangium and laban wood indicate the occurrence of narrowing of the arteries (pores) and the timber cavity although the difference is not very large compared to untreated wood. (Fig. 6-8). Narrowed this timber vessels causes both mangium and laban wood structure becomes denser and solid.



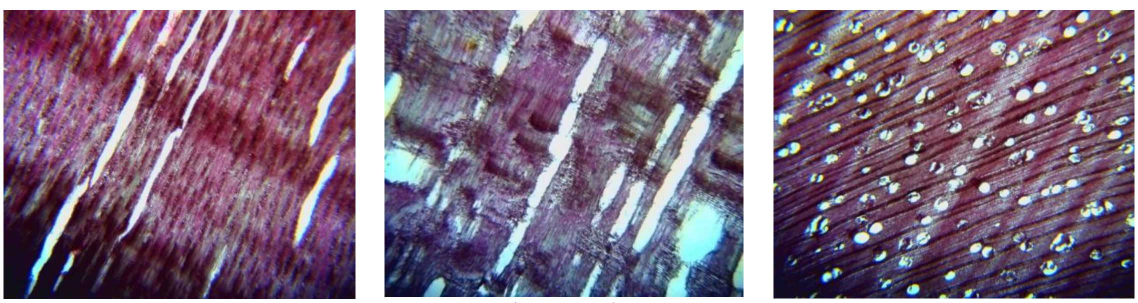
(radial) (tangential) (transversal)

Figure 6. Anatomical structure of untreated mangium wood (magnification 30x).



(radial) (tangential) (transversal)

Figure 7. Anatomical structure of fumigated mangium wood (magnification 30x).



(radial) (tangential) (longitudinal)

Figure 8 Anatomical structure of untreated laban wood (magnification 30x).

## Conclusions

Fumigation treatment of mangium and laban wood is able to reduce moisture content and increase wood density. Traditional timber fumigation by craftsman provides darker color wood and could be used for decorative timber. Timber fumigation techniques could be implemented to preserve wood for wooden crafts.

## Acknowledgement

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# Effects of Wood Modification Using Natural Resin on Wood Quality and Bonding Properties

Muhammad Navis Rofii, Ragil Widyorini, and Ganis Lukmandaru

**Abstract**

The aim of this study was to investigate the effect of gum rosin impregnation upon a low quality young teak wood in order to enhance its quality. The main objective of the treatment was to enhance the dimensional stability, as well as strength and to reduce the hygroscopicity. A 15-years old thinned teak wood (*Tectona grandis* L.f.) and gum rosin from *Pinus merkusii* Jungh. et de Vries were used for wood modification treatment by impregnation. Three kinds of non-polar solvents*, i.e.* turpentine oil, petroleum oil and *n*-hexane-, were used to make gum rosin solution. The results indicated that gum rosin impregnation did not markedly enhance the quality of young teak wood in terms of either dimensional stability or hygroscopicity; however, a little enhancement was delivered by using 15% gum rosin solution with *n*-hexane as the solvent. The treatment with petroleum oil solvent (at concentration of 7.5%) and at 15% concentration with *n*-hexane solvent resulted in highest bending properties. The highest bonding strength in dry condition was resulted by treatment with turpentine oil solvent.

**Keywords***:* wood modification, young teak wood, natural resin, non-polar solvent, wood quality, bonding properties.

## Introduction

Modifying wood through resin impregnation is commonly conducted by using synthetic resin. It has been widely taken and commercially applied. In particular, the improvement of wood's dimensional stability is primarily caused by the bulking of cell wall due to resin penetration and a cross-linking that occurred among the chemical compound of the resin within the cell wall (Hill 2006). Furthermore, resins that have been generally taken for wood modification and reported to enhance wood properties, especially its dimensional stability, include formaldehyde-based synthetic resins. Among those, the finest one is phenolic resin. At the past, water soluble phenol formaldehyde (PF) resin has been applied for *impreg* and *compreg* by Stamm dan Seborg, as reported by Hill (2006). In fact, the utilization of a certain type of synthetic resin, *e.g*. acrylic, alkyd, straight chain hydrocarbon resin and hydrogenated rosin ester, as a basic constituent in water repellent organic solutions has been reported and known as quite a common practice. Water repellent materials applied to wood provide a protection from liquid water by reducing the capillarity rates and water uptake (Voulgaridis 1993). He has also mentioned that a resinous component in water repellents is required to enhance the mechanical strength of the wood.

In general, water repellents are known as a complex mixture of different materials, *i.e.* waxes, oils, natural resin, synthetic resin and solvent (Rowell and Banks 1985; Hyvonen *et al*. 2006; Scholz *et al*. 2010). However, many typical water repellents have been recognized as having negative effects to the environment. Following an increasing environmental responsibility, including policies that favor the use of renewable resources and environmental-friendly materials, people are currently interested in developing more eco-friendly methods and utilizing biodegradable materials in wood protection to enhance the quality of wood products. Therefore, more eco-friendly water repellent materials such as tree extractives and natural resin have been successfully examined in laboratory scale (Rowell and Banks 1985; Voulgaridis 1993). Other studies have also been performed to examine the water repellency and dimensional stability of wood through a natural oil treatment and its biological efficacy (Hyvonen *et al*. 2006). Natural oils are known to have ability for inhibiting water uptake, while unsaturated oils may oxidize when in contact with oxygen from the air, which then produces a more protective layer on the wood surface.

Furthermore, one of known natural resins is gum rosin, which is obtained by distilling resins from Pines. Voulgaridis (1993) has conducted an experiment by using oleoresin and gum rosin from *Pinus halepensis* Mill. as the water repellent. The study has concluded that oleoresin and gum rosin products (grade WW, WG, N) are usable for the basic constituents of water repellent, which may then substitute synthetic resin. In this study, gum rosin from *Pinus merkusii* Jungh. et de Vries was used for wood modification through an impregnation. Besides, three types of non-polar solvents, *i.e*. turpentine oil, petroleum oil and *n*-hexane, were used to make the impregnant solution. The study is aimed to examine the effects of wood modification by conducting natural resin impregnation using gum rosin solution to enhance wood properties and its adhesion properties.

## Materials and Methods

### Specimen Preparation and Treatments

Materials used in this study include 15-years old thinned teak wood (*Tectona grandis* L.f.), gum rosin (grade WG) from *Pinus merkusii* Jungh. et de Vries as impregnant and turpentine oil as solvent were obtained from *Perum Perhutani* (Indonesia State Owned Forestry Company). Other solvents were petroleum oil obtained from gas station and *n*-hexane purchased from chemicals store. There were 35 sticks measuring 25 × 25 × 500 mm were chosen for all of treatments which were then equilibrated in an ambient condition to achieve the level of moisture content at 12~15%. Both sides were covered by paraffin to inhibit longitudinal penetration of impregnant.

Before impregnation, the samples were measured its weight and dimensions. The samples were then placed in a vacuum pressure cylinder and impregnated through a vacuum-pressure treatment by utilizing gum rosin solutions with different kinds of solvent with a concentration ranged between 7.5% and 15%. A pre-vacuum at 1 atm was applied during the first 15 minutes. During a vacuum release, gum rosin solution is pulled into the cylinder, which is followed by applying a pressure of 10 atm for 1 hour. After the treatment, the samples were taken out from the cylinder and the residual solution on the surface was wiped off and immediately weighed to calculate the absorption of impregnant. The samples were then conditioned in an ambient condition for two weeks. Their weights were then measured to determine the Weight Percent Gain (WPG) of the gum rosin solution.

### Specimen Evaluation

The samples were cut for all parameters of this study; moisture content, specific gravity and dimensional stability (total shrinkage) according to BS-373 (British Standard 1957), hygroscopicity by determining equilibrium moisture content (EMS) at relative humidity (RH) of 90% and 98% according to Sernek *et al.* (2008), and bending properties according to BS 373 (British Standard 1957). After bending evaluation, the specimens were then cut for shear bonding strength experiment and divided into two sticks. Melamine formaldehyde (MF) resin then was applied with glue spread of 40 lbs/MSGL. The samples were then clamped in a cold press for 6 hours and placed in an ambient condition for one week before being cut into specimens for shear strength test. Shear bonding strength was tested within two conditions, *i.e.* normal condition and wet condition. It was conducted by approaching to EN-314-1 (European Standard 2003). Shear bonding strength and percentage of wood failure were then determined.

## Results and Discussion

### Physical Properties

Fig. 1 shows the WPG of gum rosin solution into the wood and specific gravity of treated wood. Gum rosin solution with turpentine and petroleum oil as solvent resulted in WPG values of approximately 3.2~3.5% and 3.5~4.2%, respectively. Both of them resulted in higher WPG in concentration of 7.5% than that of 15%. It is thought that the gum rosin solution with turpentine and petroleum oil as solvent may have been more difficult to enter the wood cells. Contrarily, the solution with *n*-hexane resulted in a higher WPG at concentration of 15% than that of 7.5%. It implies that gum rosin solution with *n*-hexane solvent is easier to enter the wood cell compared to the other two solvents. In terms of specific gravity, the treatment resulted in a higher specific gravity of wood despite being insignificantly different to untreated wood with an exception for the treatment with petroleum oil solvent, which has 7.5% gum rosin solution. In particular, treated wood with the gum rosin solution at 7.5% and petroleum oil solvent have performed the highest specific gravity. The quite a little increase in terms of specific gravity for the treated wood may have been due to its little WPG values.

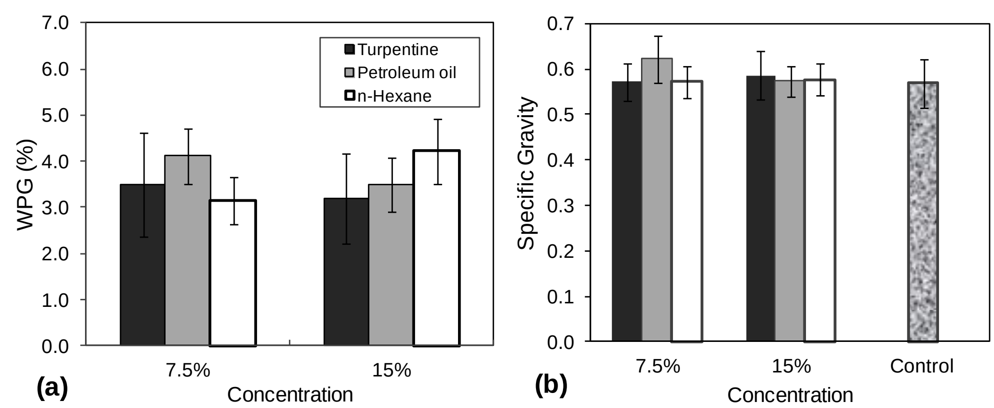


Figure 1. Weight percent gain (WPG) (a) and specific gravity (b) of teakwood treated with gum rosin at different concentrations and solvents. Error bars indicate the standard deviation.

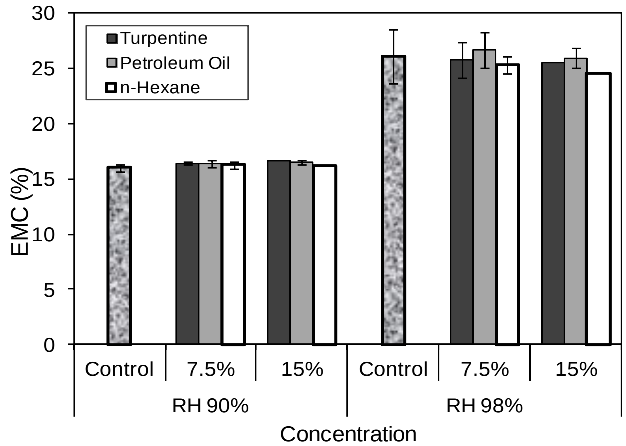


Figure 2. The equilibrium moisture content (EMC) at high relative humidity (RH) of teakwood treated with gum rosin at different concentrations and solvents. Error bars indicate the standard deviation.

The moisture content of treated wood was higher than that of untreated wood (not shown). After treatments, the amount of water may have been trapped in the wood and could not move outside the wood. This might cause a higher moisture content of the treated wood. Higher concentration of gum rosin solution resulted in a lower moisture content, except for gum rosin solution with petroleum oil as the solvent. Gum rosin solution with turpentine oil as the solvent provided the lowest moisture content of treated wood. Fig. 2 shows the EMC of treated and untreated teakwood. There was no difference between the EMC of treated and untreated teak wood. However, it appears that the treatment may have reduced the EMC of teakwood in 98% RH, especially the treatment with *n*-hexane solution. However, this reduction of EMC was not significant, indicating that the treatment with gum rosin solution as water repellent was unsuccessful to reduce water uptake.

Since impregnation treatment is aimed to improve wood dimensional stability due to the moisture, evaluating the treatment in terms of dimensional stability is important. Fig. 3 shows the total shrinkages of treated and untreated wood in tangential and radial directions. In general, the treatment did not significantly reduce the total shrinkage of teakwood. Treatments with 15% gum rosin solution with petroleum resulted in a lower tangential shrinkage than that of 7.5% solution. Gum rosin solution with 15% gum rosin and petroleum oil solvent resulted in the lowest tangential and radial shrinkages. The use of petroleum oil as solvent resulted in a better inhibition against shrinkage with the concentration of gum rosin at 15%. The use of *n*-hexane as solvent generally resulted a better application for inhibiting shrinkage, despite having resulted in a much higher shrinkage than petroleum oil solvent in a gum rosin concentration at 15%.

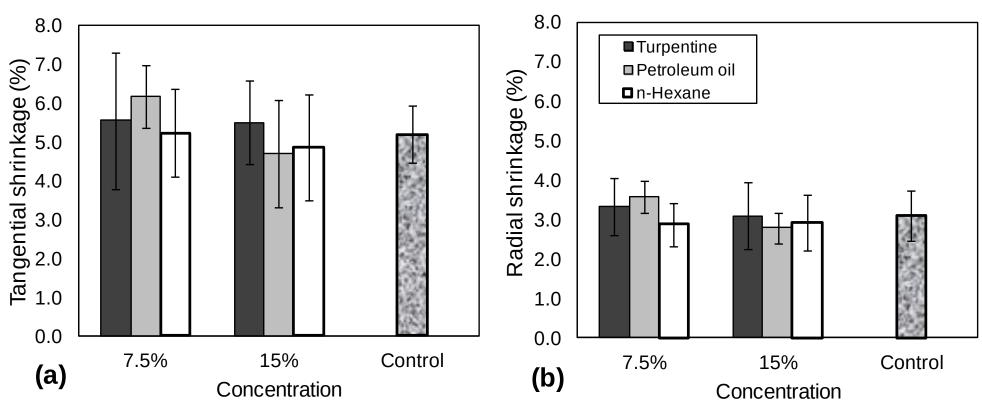


Figure 3. Total shrinkage on tangential (a) and radial (b) directions of teakwood treated with gum rosin at different concentrations and solvents. Error bars indicate the standard deviation.

## Mechanical and Bonding Properties

Wood modification by resin impregnation is also reported to enhance mechanical properties of wood. Fig. 4 shows bending properties of treated and untreated teakwood. It appears that the treatment did not affect the bending MOE and MOR in general, except for the impregnation of 7.5% gum rosin solution with petroleum oil as its solvent. The use of turpentine as solvent in gum rosin solution did not enhance the bending properties of wood. The enhancement may possibly be achieved by gum rosin impregnation with either petroleum oil solvent in both concentrations or *n*-hexane solvent at concentration of 15%.

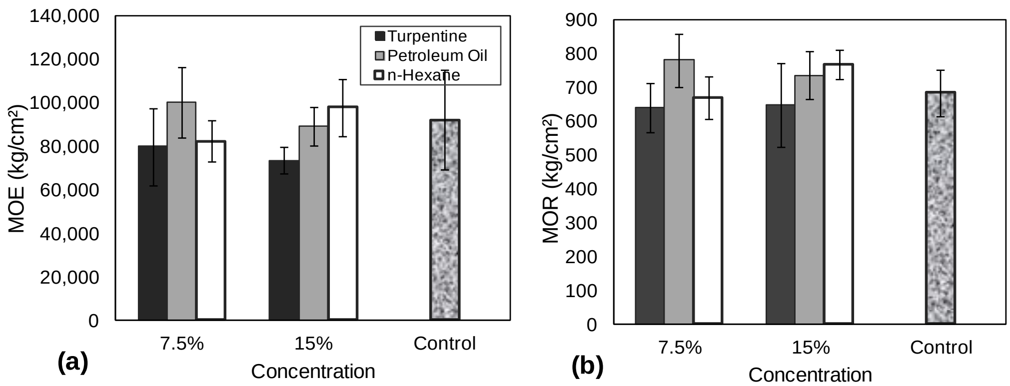


Figure 4. Bending modulus of elasticity (MOE) (a) and modulus of rupture (MOR) (b) of teakwood treated with gum rosin at different concentrations and solvents. Error bars indicate the standard deviation.

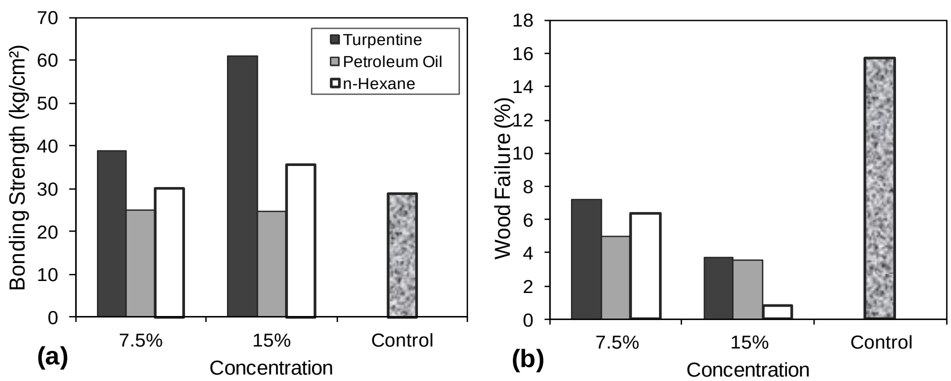


Figure 5. Bonding strength (a) and wood failure (b) at dry condition of teakwood treated with gum rosin at different concentrations and solvents.

Fig. 5 shows the shear bonding strength of the glue-line. In a normal (dry) condition, both solutions which used turpentine oil and *n*-hexane solvents provided a higher bonding strength than untreated wood, while the solution with petroleum oil solvent produced the lowest bonding strength. A higher concentration of gum rosin solution resulted in a higher bonding strength except for the solution with petroleum oil solvent. In a wet condition (not shown), the solution with turpentine oil solvent and at 15% gum rosin concentration is the only one that has a higher bonding strength than untreated wood. In terms of hydrophobicity as an objective of resin impregnation, the gum rosin with petroleum oil as solvent has been diminishing the ability of MF resin to wet the wood surface, which consequently results in a lower bonding performance. Based on the wood failure, the treatment resulted in lower wood failure than that of untreated wood. It implies that the glue-line was not strong enough to bond both wood surfaces.

## Conclusions

Wood modification through gum rosin impregnation at different concentrations and three different kinds of solvent was applied to young teak wood to enhance its quality. Based on the findings of this study, it can be generally concluded that the treatment did not enhance the quality of young teak wood in terms of either dimensional stability or hygroscopicity; however, a little enhancement was provided by gum rosin solution at 15% concentration with *n*-hexane as the solvent. On the other hand, the treatment with petroleum oil solvent and at 15% concentration with *n*-hexane solvent resulted in higher bending properties. Then, the highest bonding strength in a dry condition was obtained by gum rosin impregnation with turpentine oil solvent at concentration of 15%.

**Acknowledgement**

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# Effects of Mixing Ratio of Heavily Beaten *Pinus merkusii* Pulp on Physical Properties of Kraft *Acacia nilotica* Pulp Sheets

Ganis Lukmandaru, Fajar Setiaji, and Rena M. Siagian

**Abstract**

Paper industries commonly produce pulp sourced from a mixture of pulps, rather than from a single pulp, to obtain desired properties. In addition, the beating process is an essential step with respect to physical properties of pulp. Kraft pine (*Pinus merkusii/*PM) pulps were beaten to different degrees, i.e 200~300 CSF (heavy-beating) and 300~400 CSF (moderate-beating), paper sheets then were formed from each beaten sample. It was found that the strength properties of prepared paper sheets decreased the longer they were beaten, particularly as seen by the tear index and fold number. By microscopic investigation, it was found that cut or shortened fibers occurred very frequently in the pine pulps. Furthermore, the effects of heavily beaten pine pulp additions on handsheet properties of kraft pulps of *Acacia nilotica* (AN) were investigated. Four different mixing ratios by weight of AN/PM from 100:0, 90:10, 80:20, and 70:30 during beating, as well as four different kappa numbers of AN pulps (32.5, 34.0, 34.2, and 35.9) were applied. In general, the decrease in strength properties (3~25%) that occurred with increasing pine pulp ratio was more evident between pulp without pine and a 30% ratio of pine pulps. Fold number was reduced considerably (2.8~24.7%) by the blend composition but less pronounced in tear index (3.0~8.9%) from the initial values. However, the 10% or 20% ratio of PM pulps could increase opacity, brightness, and strength properties in some cases. No clear trend was found with increasing kappa number.

**Keywords:** mixture pulp, long fiber, pulp beating, pulp strength, optical properties.

## Introduction

The pulp and paper industry in Indonesia produce mainly mixed tropical hardwood pulps with short fibers. The *Acacia mangium* wood is one of the preferred raw materials. On the contrary, the source of raw material with long fibers is limited to *Pinus merkusii*. Therefore, to meet the demand of long fibers, Indonesia is dependent on imports. In view of the high demand on a domestic level for paper and in order to reduce imported pulps, it is necessary to further identify the local fibrous raw materials and evaluate their suitability for pulping. Beside *Acacia mangium*, *Acacia nilotica* is a widely distributed species in some areas in Indonesia and is easy to grow. In Baluran National Park, particularly, its presence demonstrates a fast growing and invasive behaviour.

The potentialities of *Acacia nilotica* (AN) wood were assessed for their suitability for papermaking (Khristova *et al*. 1997; Lukmandaru *et al*. 2002; Onuorah *et al*. 2014). The pulps met the standard for printing-, writing- and wrapping-papers. It was noted that the unbleached pulp of AN wood from Indonesia was still dark (brightness of 15.78~17.13%) and showed a high kappa number (31.8~36.3) for further bleaching process (Lukmandaru *et al*. 2002). This suggests that this material would be more suitable for unbleached end-products, such as wrapping papers or kraft-liners.

In the practice, it is necessary to utilize pulp mixtures to improve the specific characteristics of final paper that cannot be obtained by just one type of fiber (Shmulsky and Jones 2011). For years, long fiber pulps have been used to improve both wet and dried strengths in paper in order to increase paper machine runnability (Walker 2006; Nordström and Hermansson 2017). In case of kraft-liners, the mixture consists of strong softwood kraft pulp with long fibers and a relatively weak pulp with short fibers. The pulp mixture is possible in both mixed refined pulps and separately refined pulps (Chauhan *et al*. 2011; Azeez *et al*. 2016). It is already known that excessive beating of long fiber pulp is avoided as it deteriorates some physical properties of the resulting paper. However, excessive beating is frequently applied in recycled pulps where cutting or shortening of fibers often occurs. It is thought that mixtures of different pulps would behave additively in paper. Unfortunately, studies with regard to the additional effect of a strong degree of beating/refining of long fiber on pulp handsheets of short fiber pulps are scarce. Thus, this study aims to evaluate the effect of the addition of soft wood i.e. *Pinus merkusii* pulps prepared by intensive beating to *Acacia nilotica* kraft pulps on the final paper product's physical properties at a laboratory scale.

## Materials and Methods

### Sample Preparation

The *Pinus merkusii* (PM) tree (wood SG = 0.57) of 15 years old in this study was taken from Perhutani plantation in Purworejo, Central Java Province whereas *Acacia nilotica* (AN) tree (wood SG = 0.86, dbh = 25 cm) was felled in Baluran National Park, Situbondo, East Java Province. Then, the samples from the bottom parts were chipped manually, to dimensions of 30 × 30 × 2~3 mm for pulping.

The wood chips were then air-dried and dry-stored until the initiation of pulping.

### Kraft Pulping

Kraft cooking of AN was performed using a laboratory type circulated autoclave (M/K System Inc.) in triplicate. The amount of 450 g oven-dried equivalent chips per cook were pulped using conditions : varied active alkali as $Na_2O$ (15%, 16%, 17%, 18%); 25% sulfidity; 4:1 liquor/wood ratio, 170°C cooking temperature, 120 min to cooking temperature and 90 min at cooking temperature. The pulping condition of PM chips was similar to AN chips except for an active alkali level of only 20% rather than multiple amounts. After digestion, the black liquor was removed by washing and the cooked pulps were screened to separate the fibers from the rejects. The screened yield (through a 60-mesh screen onto a 80-mesh) and reject were counted as a percentage of their oven-dried mass of chips. The pulps were then disintegrated in a laboratory-type pulp mixer. Kappa number was measured according to SNI 14-0494-89.

### Pulp Beating

The pulp freeness was determined according to the Canadian Standard Freeness (CSF) method (TAPPI standard method T-227 om-92). The unbleached pine pulps at a consistency of 3% were beaten to 200~300 CSF and 300~400 CSF in PFI mill no. 236 according to TAPPI T200. The unbleached AN pulps were blended with PM pulp in four mixing ratios (100:0, 90:10, 80:20, 70:30) by weighing their appropriate amounts. The mixtures then were subjected to beating to achieve a freeness of 200~300 CSF. The beating duration to obtain 250 CSF was calculated by intrapolation on the basis of the intial degree of freeness.

### Physical Properties of Pulp

Handsheets in 60 g/m$^2$ basis weights were prepared from beaten pulps using a sheet former (SNI 14-0489-1989). Pulp handsheets at each level of mixing ratio (0%; 10%; 20%; 30% addition of PM pulps) as well as different kappa numbers of AN pulps were made. Handsheets were kept overnight and allowed to condition at 23 ± 1°C and 50 ± 2% relative humidity before testing (SNI 14-0402-1989). The tensile, bursting, and tearing strength, fold number, as well as thickness values were obtained according to SNI 14-0437-1989, SNI 14-0493-1989, SNI-14-0436-1989, SNI 14-0491-1989, and SNI 14-0439-1989, respectively. The brightness and opacity of handsheets were also measured using a Photovolt Reflectometer that conformed to SNI 14-0495-1989 and SNI 14-0438-1989, respectively.

### Measurement of Fiber Dimension

A portion of beaten pulp of single species was measured for its fiber dimensions by microscopic image. Fiber diameter and length was measured and recorded with a light microscope with a digital camera (Olympus BX 51; Olympus Coorporation; Japan). Furthermore, image-analysis software (Image pro Plus) was utilized to measure the fiber dimension. Simple fractionation was based on the results of fiber dimension measurements. The fractionation resulted in the composition of intact fibers, fiber fragment, and fines with 5 specimens classified per single species.

## Results and Discussion

### Yield and Kappa Number

Pulping was carried out for two species i.e. PM for long-fiber source and AN for short-fiber. The yield and kappa number determination is presented in Table 1. The PM pulping was done by high active alkali concentration (20%) to obtain a kappa number below 20. The yield obtained was in the normal range of hardwood for commercial pulping but lower than previously reported (Lukmandaru *et al*. 2004). On the contrary, the kappa number of AN pulp was still high (32~35) although the active alkali used was 18%. In general, the increase of active alkali levels up to 16% was followed by the increase of screened yield (39~48%) and decrease of the rejects (11~1%) of AN pulps. With regard to total yield levels (46~51%), the increase started at the active alkali of 17% which is assumed to be the beginning of intensive degradation of polysaccharides.

The kappa number indicates the residual lignin in pulp as well as the degree of delignification achieved during pulping. The comparatively high kappa number of AN pulps could be ascribed to higher specific gravity of the wood (0.86) compared to those of other Acacia species (Haroen and Dimyati 2006; Jahan *et al*. 2008; Yahya *et al*. 2010). It assumed that high density caused less intensive liquor penetration. The levels of yield and kappa number obtained here was in the range of the values of earlier studies on AN kraft pulps (Khristova *et al*. 1997; Lukmandaru *et al*. 2002; Onuorah *et al*. 2014).

Table 1. Yield and kappa number of kraft cooking of *Pinus merkusi* and *Acacia nilotica* chips.

| Measurement | Screened yield (%) | Reject (%) | Total yield (%) | Kappa number |
|---|---|---|---|---|
| Pine | 46.47 (1.35) | 2.25 (0.74) | 48.73 (2.10) | 13.1 (0.2) |
| AN-AA15% | 39.20 (0.56) | 11.07 (3.75) | 50.27 (4.32) | 35.9 (1.8) |
| AN-AA16% | 48.38 (2.06) | 2.68 (0.40) | 51.06 (2.46) | 34.0 (0.8) |
| AN-AA17% | 47.24 (2.77) | 2.33 (1.82) | 49.58 (4.59) | 34.2 (0.7) |
| AN-AA18% | 45.12 (2.98) | 1.02 (0.45) | 46.15 (3.44) | 32.5 (0.2) |

Remark : AN = *Acacia nilotica*, AA = active alkali concentration. Mean of 3 measurements with standard deviation on parentheses.

## Physical Properties of Pine Pulp

Beating or refining is the crucial mechanical treatment applied to pulp before paper making (Walker 2006). It causes fiber conformability and increases the bonding area in paper (Manfredi 2006; Corson 1980). However, high intensity beating causes shortening of the fiber length formation of fines, and decreased fiber strength (Casey 1981; Page 1989). A beating degree between 300 and 450 ml CSF is a typical, acceptable value for papermaking (Shakhes *et al*. 2010). Further beating of pine pulp causes a considerable decrease both in the tear index and the apparent specific volume (Danielewicz and Surma-Ślusarska 2004). To discover the effects of beating, PM pulps were beaten to 200~300 CSF (heavy-beating) and 300~400 CSF (moderate-beating). Pulp handsheets at each level were made and the physical properties were examined (Table 2). The results demonstrated that heavy-beating reduced the strengths considerably, in particular, tear index (reduced to 71.4%) and fold number (reduced to 93.9%). On the other hand, an increase was only found in brightness. Thus, the magnitude of reduction was considered to be sufficient to evaluate the pulp mixtures for the next step.

Table 2. Physical properties of *Pinus merkusii* pulp in different beating degrees.

| Measurement | 300~400 CSF | 200~300 CSF | Percent reduction (%) |
|---|---|---|---|
| Thickness (x $10^{-3}$) cm | 205.80 | 136.25 | 33.7 |
| Brightness (%) | 20.7 | 24.3 | -17.3 |
| Opacity (%) | 91.7 | 87.9 | 4.1 |
| Tear index ($Nm.m^2.g^{-1}$) | 49.19 | 14.04 | 71.4 |
| Tensile index ($Nm.g^{-1}$) | 41.15 | 35.62 | 13.4 |
| Burst index ($kPa.m^2.g^{-1}$) | 4.15 | 3.72 | 10.3 |
| Fold number | 719.6 | 43.6 | 93.9 |

## Duration of Beating

Beatability of pulps, expressed by freeness, indicates the energy consumption of mills and mostly is affected by the chemical composition of pulps (Gulsoy and Tufek 2013). Furthermore, beatability has a significant role in affecting drainage characteristics of paper machines. AN pulps with varied kappa number then were mixed with different ratios of PM pulps on the basis of their weights. The pulps were then beaten to 200~300 CSF.The initial beating degree of unmixed AN pulps ranged from 740 to 760 CSF whereas PM pulps were 730~740 CSF. The linearly intrapolated beating time to achieve 250 CSF was calculated both for mixed and unmixed pulps (Table 3). Judging by the kappa number, it was noticed that the more intensively-cooked PM pulps required a longer beating duration (23.5 mins) than the AM pulps (11~13 mins). This was probably due to the longer and thicker fiber of PM pulps. This approach has previously been put forward in a study of kenaf (Shakhes *et al*. 2010). In general, the addition of PM pulps in amounts of 10% and 20% increased the beating duration whereas the amount of 30% decreased the beating duration. At this time, the explanation for such a finding remains uncertain.This finding may be due to a complex interaction of the low kappa number and high fiber dimension of PM pulps against the AN pulps. Results also showed that the more delignified AN pulp (kappa number 32.5 and 34.0) did not show an increasing beating duration with 10% addition of PM pulps. These differences may be due to the lower residual lignin content which results in easier beating. Previous study demonstrated that the relationship between beating time and the kappa number was positively linear (Gulsoy and Tufek 2013).

Table 3. Beating duration to 250 CSF of mixture pulp of *Pinus merkusii* and *Acacia nilotica*

| Pulp material | Initial freeness (CSF) | Duration to 250 CSF (min) |
|---|---|---|
| Pine - 100% | 730~740 | 23.5 |
| AN1 - pine 0% | 740~755 | 12.3 |
| AN1 - pine 10% | 725~735 | 17.3 |
| AN1 - pine 20 % | 730~740 | 11.1 |
| AN1 - pine 30 % | 735~745 | 10.1 |
| AN2 - pine 0% | 745~755 | 11.3 |
| AN2 - pine 10% | 740~750 | 17.5 |
| AN2 - pine 20 % | 735~765 | 12.1 |
| AN2 - pine 30 % | 730~735 | 11.2 |
| AN3 - pine 0% | 740~745 | 12.5 |
| AN3 - pine 10% | 725~750 | 13.3 |
| AN3 - pine 20 % | 750~755 | 10.5 |
| AN3 - pine 30 % | 750~755 | 11.7 |
| AN4 - pine 0% | 745~760 | 11.9 |
| AN4 - pine 10% | 745~760 | 12.7 |
| AN4 - pine 20 % | 735~755 | 12.2 |
| AN4 - pine 30 % | 735~740 | 11.6 |

Remark : AN1, AN2, AN3, and AN4 are *Acacia nilotica* pulps with kappa number 35.9; 34.0; 34.2; and 32.5, respectively.

### Fiber Dimension after Beating

Samples of unmixed pulps after beating were measured for their fiber dimension. The microscopic and measurement results are described in Table 3 and Fig. 1. As expected, the intact PM fibers were longer (1.956~4.577 µm) and wider in diameter compared to those AN fibers (1.160~1.307 µm). This trend also applied to slenderness ratio (47~82) causing higher values of tear strength of PM pulps. Previous data for PM showed that the values of fiber length, fiber diameter, and slenderness ratio before beating were 4.771 µm, 47 µm, and 115, respectively (Pasaribu and Roliadi 1990) whereas for AN were 1.133 µm, 18 µm, and 63 (Onuorah *et al*. 2014).

In unbeaten chemical softwood pulps, the amount of fiber fraction is 95~100% (Paavilainen 1990). The fiber fraction is mainly composed of intact fibers with different lengths. Chemical pulps generate primary fines (0~5%) and consist of parenchyma cells, fiber pores, and short cut fibers whereas secondary fines formed after refining consist of flexible fibrils, fiber wall fragments, and short cut fibers (Paavilainen 1990; Waterhouse *et al*. 1993). It can bee seen that there was an extensive fiber shortening of the PM pulp during heavy beating. Furthermore, fiber conditions can be categorized as intact fibers, fiber fragments, and fines (Fig. 1). By simple fractionation through the microscopic images, the portions of each part were calculated. To facilitate the interpretations, the PM pulps were divided into 3 dimensions of fiber fragments (Table 4). The intact fibers of PM showed a small percentage (0~12%) as the intact AN fibers had considerable portions (52~72%). This result was probably due to the combination of the low kappa number of PM pulps (13.1) and high refiner energy. As this method only gave a rough description, it is necessary to employ fiber classifier machine for more accurate data. Furthermore, the actual fiber composition remained unknown as the fiber dimension of mixture pulps after beating were not measured in this experiment. The beating properties of a pulp mixture might behave differently from a single fiber pulp.

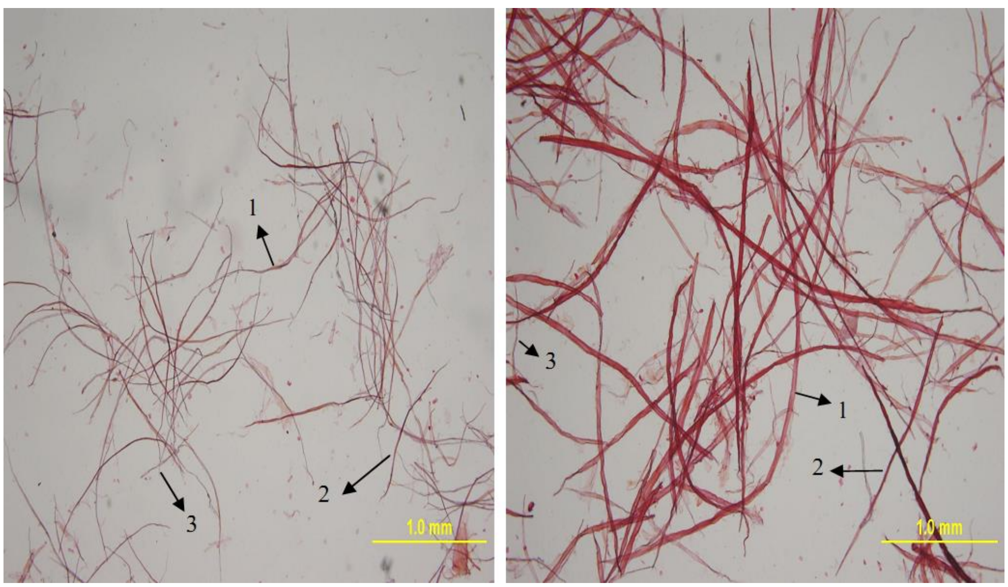


Figure 1. Microscopic images of *Acacia nilotica* (a) and *Pinus merkusii* fibers after beating (200~300 CSF). Remark 1 = intact fibers, 2= fiber fragments, 3=fines.

Table 4. Fractionation of *Acacia nilotica* (a) and *Pinus merkusii* fibers after beating (200~300 CSF) based on microscopic images.

| Species | Length (µm) | Width (µm) | Slenderness ratio | Percentage (%) |
|---|---|---|---|---|
| Nilotica pulp | | | | |
| - Intact fibers | 1.160-1.307 | 18-22 | 18-64 | 52-72 |
| - Fiber fragments | 478-628 | 18-21 | 26-30 | 25-42 |
| - Fines | < 300 | < 15 | < 13 | 4-8 |
| Pine pulp | | | | |
| - Intact fibers | 1.956-4.577 | 41-56 | 47-82 | 0-12 |
| - Fiber fragments – long | 1.364-1.983 | 41-46 | 33-44 | 31-46 |
| - Fiber fragments – medium | 878-1.094 | 24-28 | 36-40 | 18-32 |
| - Fiber fragments – short | 522-834 | 18-25 | 29-34 | 16-32 |
| - Fines | < 300 | < 15 | < 20 | 6-14 |

**Physical Properties of Mixtures Pulp**

The strength and other properties of hand sheet made from mixed beating of pulps are either better or comparable than those of separately beaten pulps (Chauhan *et al*. 2011). After beating, the handsheets were formed at a target basis weight 60~70 g/cm$^2$ and were tested. The results of thickness, brightness, and opacity measurements are displayed in Fig. 2. The thickness (136.2 x 10$^{-3}$ cm) and brightness (22.53%) values of unmixed PM pulps were higher but lower in opacity (87.97%) than those of unmixed AN pulps. It is expected that fines fraction would increase the opacity and decrease fiber density (Görres *et al*. 2001). In general, an increase in PM pulp amounts resulted in an increase in brightness and decrease in thickness. It appeared that thickness and brighness behaved additively as a function of their mixing ratio. This can be explained by considering that extra fines tend to compact the paper sheet but reduce its density and thickness. However, no clear trend was observed with regard to opacity. Perhaps this result came from the fact more fiber fragments will in turn give a more open structure, albeit to a small degree, and consequently reduce light scattering. On the basis of kappa number, brightness decreased with increasing kappa number (Fig. 2c). The AN pulps with kappa number 34.2 tended to give the highest values on handsheet thickness (Fig. 2a).

Remarkable differences were found between unmixed and 30% ratio of PM pulps. On the other hand, the addition of 10% and 20% showed a fluctuating curve for brightness and thickness levels. The thickness decreased 3.69~11.19% from the initial values (156 x 10$^{-3}$ cm ~ 193 x 10$^{-3}$ cm) after the 30% addition of PM pulps. The same treatment could increase brightness 4.1~11.5% on the basis of unmixed AN pulps (15.7~17.2%). Although the increase percentage was small (0.1~0.8%), it was found that the 20% ratio of PM pulps achieved the highest opacity based on initial values (98.4~99.5%) with the exception of AN pulps with kappa number of 32.5. Furthermore, pulps with a high kappa number (35.9) tended to have low brightness.

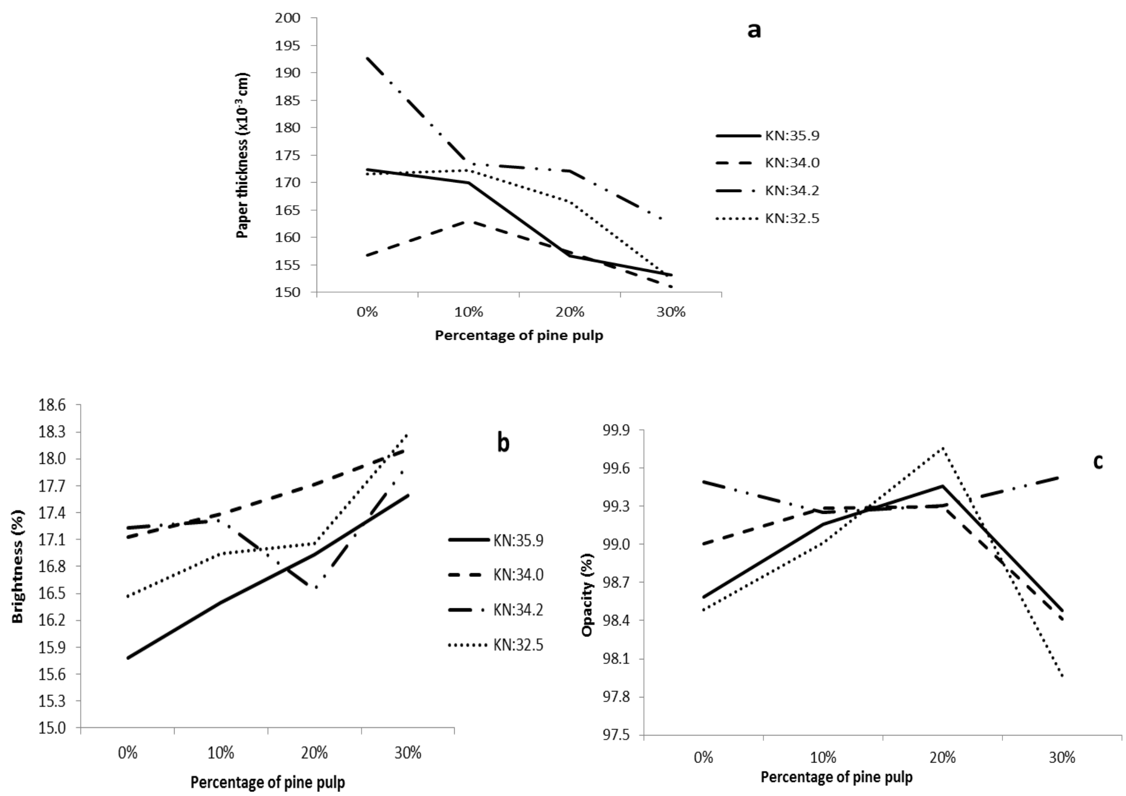


Figure 2. Measurements of handsheets thickness, brightness, and opacity of *Acacia nilotica* and *Pinus merkusii* pulps. Remark : KN = kappa number.

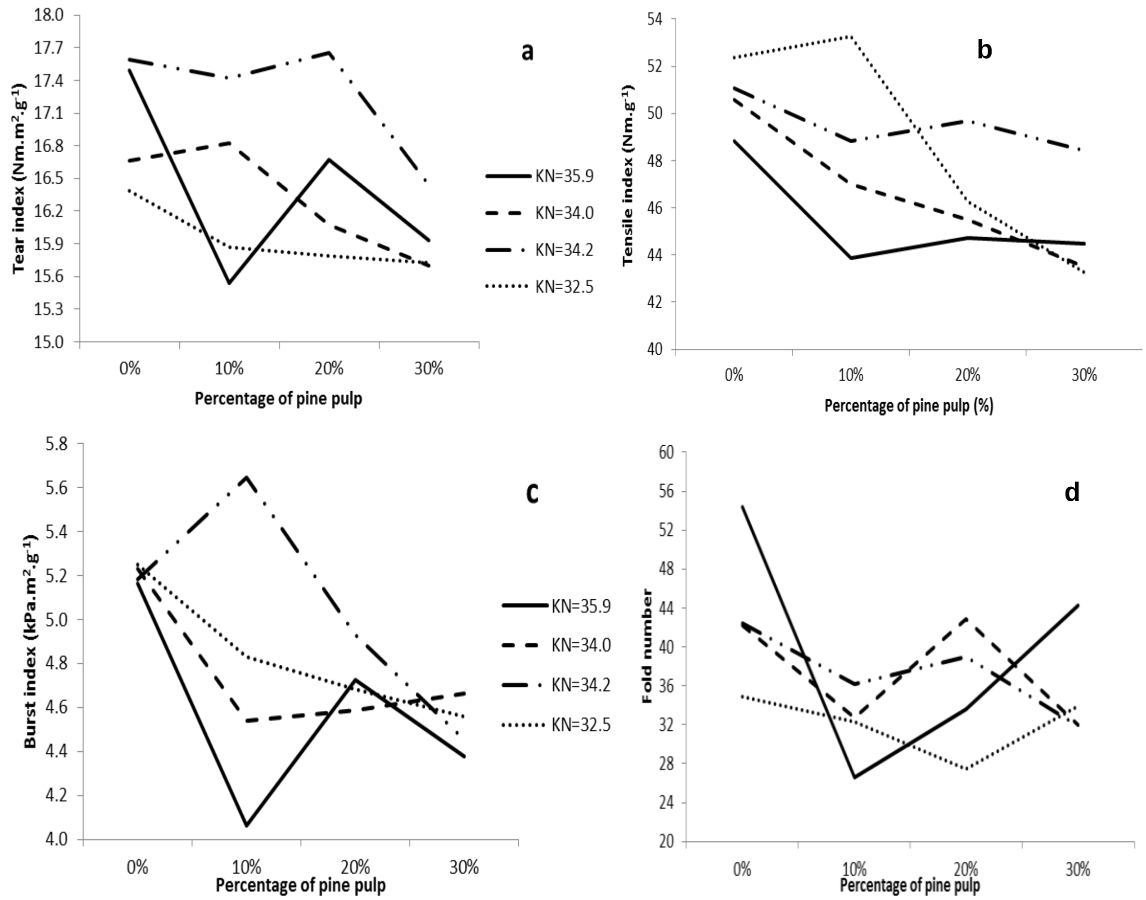


Figure 3. Measurements of strength properties of *Acacia nilotica* (a) and *Pinus merkusii* pulps. Remark : KN = kappa number

Several previous studies related to mixed pulping of several hardwood and softwood species were reported (Danielewicz and Surma-Ślusarska 2004; Chauhan *et al*. 2011; Gulsoy and Tufek 2013; Nordström and Hermansson 2017) as well as studies on PM pulp mixing in Indonesia (Yasin *et al*. 1984; Rismijana *et al*. 1992). These studies mostly discussed the enhancement of strength properties after long-fiber addition. The mixture of different kraft pulps of AN and PM, could be assumed to behave in a nonlinear manner as a function of the mixing ratio of the pulps as their properties were not similar. The determination of pulp strength is presented in Fig. 3. In general, the strengths decreased as a result of adding PM pulps whereas no distinct pattern was found with increasing kappa number.

The tear index of unmixed PM pulps was 14.24 $Nm.m^2.g^{-1}$ compared to 16.3 $Nm.m^2.g^{-1}$ ~17.5 $Nm.m^2.g^{-1}$ of unmixed AN pulps (Fig. 3a). PM pulp could reduce the strength of the paper sheets 3.0~8.9% based on its initial values by 30% ratio whereas the 10% or 20% ratios showed more varied patterns. The highest values of tear index (17.65 $Nm.m^2.g^{-1}$) of unmixed AN pulps were measured in 30% addition of PM pulp samples (kappa number = 34.2). The fold numbers of unmixed AN pulps ranged from 34~55 (Fig. 3d) whereas the average value of unmixed PM pulps were 43. Based on the initial values, the 30% ratio of PM pulps decreased the strength by 2.8% to 24.7%. Except for AN pulps with a kappa number of 34.0, the fold number of handsheets with 10% ratio had higher values than those of 20% ratio of PM pulps.

The unmixed AN pulps had a tensile index of 48.81 $Nm.g^{-1}$ ~ 52.37 $Nm.g^{-1}$ (Fig. 3b); as for PM pulp, the tensile index was 37.47 $Nm.g^{-1}$. A reduction of strength (8.8~17.3%) was observed for 30% ratio of PM pulps. A strength enhancement (53.27 $Nm.g^{-1}$) equal to 1.71% of initial value was found in the AN samples (kappa number = 32.5) with 10% ratio of PM pulps. PM pulps lowered the burst index 10.1-15.1% of its unmixed AN pulps (5.16 $kPa.m^2.g^{-1}$ ~ 5.25 $kPa.m^2.g^{-1}$) by 30% addition. A burst index increase of 9.0% (5.65 $kPa.m^2.g^{-1}$) was observed only in the AN samples (kappa number 34.2) as a result of adding 10% PM pulps. By comparison, unmixed PM pulps had burst index of 3.86 $kPa.m^2.g^{-1}$.

The sum of the fiber strength and the fiber network properties result in the strength properties of a fiber network. Thus, fiber damage and fiber deformations would decrease the initial strength. Of all strength properties measured, fold number was mostly reduced (2.8~24.7%) by the blend composition but there was a less pronounced decrease in tear index (3.0~8.9%). Theoretically, tearing resistance was affected by total number of fibers participating in the sheet rupture, fiber length and number and strength of the fiber to fiber bond (Casey 1981). It was thought that the shortening of fibers did not substantially reduce the tear strength as the cut fiber of PM were mostly similar in length to AN fibers (Table 4). The strength of AN fibers slightly improved at first (10% or 20% ratio of PM pulps) in some samples, but then decreased at 30% ratio. At small share, fines fraction probably would provide the needed bonding. Pulp sheets prepared from material with a small degree of damaged fibers (dislocated fiber walls, curls and kinks) will have improved stretch and tear indices compared with pulp sheets prepared from fibers lacking deformations (Kibblewhite 1976; Page *et al*. 1985). The strength reduction at 30% ratio of PM pulp might be caused by extra fines would separate fibers from each other thus starting to break their unified network. Further investigation is required to determine whether the presence of fines or other kinds of fiber damages will affect the strength reduction.

## Conclusions

Heavy-beating caused more fines and extensive fiber shortening of PM as observed from microscopy images. However, adding PM pulps to AN pulp did not affect the beating duration considerably. The effects on thickness, paper strength, and optical properties of blending pine and AN kraft pulps during beating in various proportions have been examined. The kappa number of AN pulps did not show a clear correlation with the physical properties of the sheets. Although it was not applied in all samples, the 10% or 20% addition of PM pulps caused handsheet opacity and strengths to be increased in varying degrees. The effect of adding different proportions of PM pulps improved brighness but reduced thickness with increasing amounts of PM pulps. The strengths generally decreased in varying degrees at 30% ratio of PM pulps. Tear index, however, was less affected than the other measured strengths. The results of this study suggest that the high proportion of fines generated during heavy-beating causes poor bonding.

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# Ethnopharmacological Study on Traditional Knowledge of Medicinal Plant Used from Secondary Forest in Community at Sekabuk Village, Mempawah District, West Kalimantan, Indonesia

Yui Hashimoto, Fathul Yusro, Yeni Mariani, Farah Diba, and Kazuhiro Ohtani

**Abstract**

Study for local knowledge about ethnopharmacology especially medicinal plants used by the community is still limited. West Kalimantan possess a tropical rain forest with megabiodiversity. One of the areas where Malay and Dayak people use medicinal plants from the forest is Sekabuk village, Sadaniang Subdistrict, Mempawah District of West Kalimantan, Indonesia. This research has two objectives: first, to summarize the local knowledge of medicinal plants in the Sekabuk village, and second to identify the the mechanisms of shared on knowledge on used the medicinal plants on each ethnic. The research was conducted by in-depth interview and survey for 45 days in the village. The research programme consisted of interviews, plant observations, and a collection of medicinal plants from five different subdistricts sites i.e. Gelombang, Malangga, Pak Nungkat, Sekabuk, and Titi Dahan. The whole plants, part(s) used, and remedy formulations were elicited from healers and voucher specimens were collected for identification and stored at Forestry Faculty, Tanjungpura University. The results showed that there are 66 plants used for medicine. The family of plants consisted of Zingiberaceae, Lamiaceae abd Mrytaceae. The leaves were most frequently used (108), followed by roots (47), whole plant (21), top (6), stems and fruits (5), and sap (1). The methods for preparation and administration and the awareness of medicinal plants are different by ethnic groups and the living environments. The difference between the genders did not significant in terms of knowledge about medicinal plants. Meanwhile, A retention of traditional knowledge of medicinal plants was significant in rural of West Kalimantan. The plants used as medicine were clearly different by ethnic groups, Malay and Dayak. The living environments also affect the difference of used plants on basis of plants accesibility.

**Keywords:** ethnic groups, knowledge distribution, living environments, local knowledge, medicinal plants, West Kalimantan

## Introduction

Most of Indonesian people use traditional herbal medicines known as *jamu* to treat diseases. *Jamu* is a term in Javanese language, meaning the traditional medicine from plants, but it is now adopted into Indonesian language with the similar meaning. Recently, *jamu* becomes modern medicine, and related products are manufactured in many industries (Elfahmi *et al*. 2014). Thus, Indonesian have benefit from herbal medicines. On the other hand, people who live in rural and remote areas have employed plants as traditional medicines since earlier time. *Jamu* is distinguished from plant-based traditional medicine. *Jamu* is written the prescriptions in the form called ‘serat’ or ‘primbon’ by Javanese people (Riswan *et al*. 2002). By contrast, local knowledge of herbal medicine has accumulated and has been transmitted from age to age by word of mouth and by life style in rural area or among ethnic minorities (Inta *et al*. 2013). In Indonesia, number of uninsured individual reaches approximately 40% of nation, because an official healthcare insurance system for whole nation didn’t exist until 2014 (Republik Indonesia 2012). Thus, the local people still use plants as the traditional medicine in substitution for treatment by doctor in healthcare center. Although recently local medicinal knowledge is spreading recognition that it is important in primary healthcare system, inexpensive modern medicine like tablet, capsule and liquid has spread across rural areas. Subsequently, the loss of their local knowledge has been progressed.

Indonesia has the second biggest biodiversity in the world after the Amazon forests (Elfahmi *et al*. 2014) and more than 300 ethnics domicile (Silalahi *et al*. 2015). Most of studies have focused on inhibitory activities against particular diseases or specific medicinal plants in Indonesia. Although the traditional knowledge of plant usage as medicine has studied by Indonesian researchers, most studies have not been published in international journals. Especially literatures concerning West Kalimantan are extremely rare. The interactions and relationships between the biological and cultural elements of the environment (Bye 1986) and the influence of the cultural and ecological factors on medicinal plant selection by ethnic groups were examined (Joshi and Edington 1990); Junsongduang *et al*. 2014; Silalahi *et al*. 2015). Although the difference in utilization of traditional medicine has been reported on these studies, rare report is available about those in Indonesia. Additionally, most research was carried out in one village where one ethnic group live.In this study we carried out research in one village which has two characteristics: different ethnic groups live and a community locates away from others. This research had two objectives: (1) to summarize the local knowledge of medicinal plants in this village; and (2) to identify their knowledge shared by all inhabitants or each ethnic group.

## Materials and Methods

### Research Site

This fieldwork was conducted in Sekabuk village, Sadaniang Sub-district, Mempawah District in West Kalimantan, Indonesia. This village is approximately located 110km from the capital city Pontianak (Fig. 1). Five communities, Gelombang, Malangga, Pak nungkat, Sekabuk and Titi Dahan live in the village. The indigenous people are Dayak 69%, Malay 21%, Chinese 8%, and other 2%. The population is about 2,000 (BPS 2013). Malay people live in the community, Pak nungkat is separated from other, but other ethnicities such as the Dayak people live together in other communities. Meanwhile,Sekabuk community is maintained in the center of the village, and Gelombang community is apart from other communities with 20 houses.

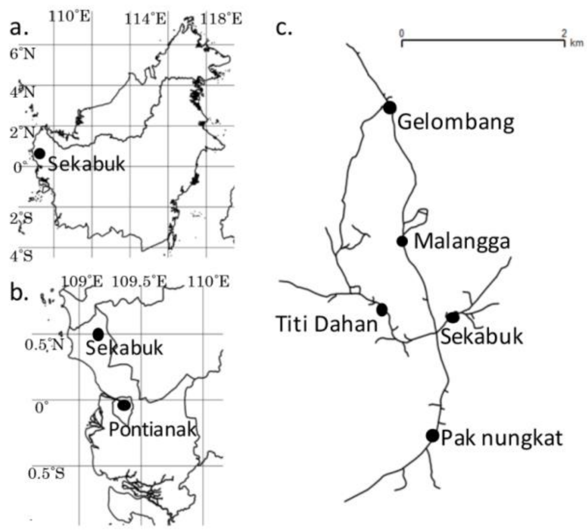


Figure 1. Research Site in Sekabuk Village Mempawah District West Kalimantan.

### Data Sampling

Fieldwork was carried out at Sekabuk village Mempawah District West Kalimantan. The communities in this village still used the medicinal plants from the forest for their daily use and treat the diseases. The work consisted of interviews, plant observations, and a collection of medicinal plants in five different sites: Gelombang, Malangga, Pak Nungkat, Sekabuk, and Titi Dahan. Ethnobotanical data was collected through semi-structured interviews twice. During the first round of the survey, we interviewed 66 family units at Gelombang (n=9), Malangga (n=7), Pak nungkat (n=30), Sekabuk (n=5), and Titi Dahan (n=15). The informants were asked about their knowledge of the plants to treat diseases, the used parts, the modes of preparation and administration, the collection sites, and the plant types (native or cultivated). During the second survey, we interviewed 100 local people at Gelombang (n=5), Pak nungkat (n=34), Sekabuk (n=25), and Titi Dahan (n=36). Whereat we could not get cooperation from the people of Malangga community. We proceeded with the investigation without Malangga data. Awareness rate of medicinal plants were collected using a questionnaire – a checklist consisted of 66 species' names which were mentioned in the first fieldwork. The interviewees were randomly selected, and there were no meetings prior to the sampling. The plants were collected, pressed and then dried in the field, and the voucher specimens were later deposited at the Tanjungpura University. The vernacular names were collected through the help of local people. Scientific names of plants were expressed based on *The Plant Names Index* (IPNI 2005). The Welch's test was used to determine whether there were significant differences between known medicinal plants.

## Results and Discussion

### Characteristics of Medicinal Plants

A total of 66 different species were recorded for medicinal uses. They belonged to 34 families and were used to treat 46 ailments (Appendix 1). Five out of the 66 species were not identified yet, but the family name for two out of the 5 unidentified species were identified. In terms of the number of species used, Zingiberaceae and Lamiaceae (n=7) were the most used families followed by Myrtaceae (n=5). Zingiberaceous plants exist in about 50 genera and 1,300 species worldwide, distributed mainly in South and Southeast Asia. Plants of this family contain various type of essential oils, including terpenes, alcohols, ketones, flavonoids, carotenoids and phytoestrogens (Chen *et al*. 2008). Many of lamiaceous plants are used as many medicinal plants because of their rich and fragrant essential oils which are principally composed of monoterpenes (Yamane *et al*. 2010).

**Type of Medicinal Plants**

Medicinal plants were collected in the forest by individuals or by their family members. Medicinal herbs were either cultivated by the residents (53%) or harvested from the wild (46%) (Fig. 2). In other words, native plants were reported rather than cultivated plants: 82% (Giday *et al*. 2003), 58% (Kichu *et al*. 2015) respectively. Fig. 2 revealed that ratio of native and cultivated plants were different by community. It shows that cultivated plant rate is high in Titi Dahan and Pak nungkat. People of these communities have the habit of transplanting near homes to use as medicine, because the utilization rate of these medicinal plants is also high. On the other hand, it was indicated that native plant rates is high in Gelombang and Sekabuk. Sekabuk community reported low frequency of use of medicinal plants for everyday use. The residents do not have the custom of cultivating medicinal plants, so that they did not report on their daily use. In the case of Gelombang, it is associated that this community is located near the mountain. There was a tendency to use a plant that grows wild in mountains.

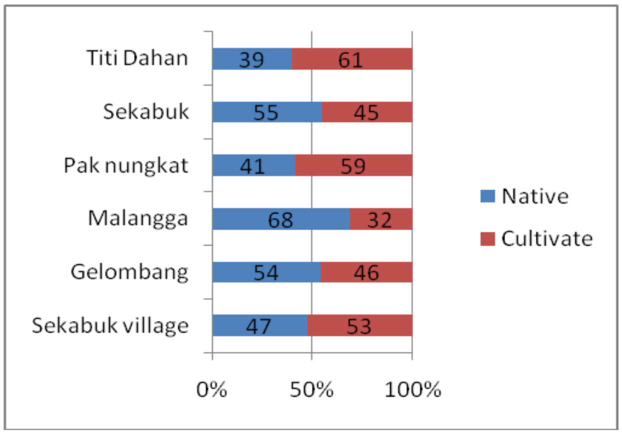


Figure 2. The proportion of medicinal plants which were cultivated and gathered in wild.

Table 1. The number of use reports and their ratio (%) of total uses for medicinal plant, used parts, preparation and administration by each community of Sekabuk village.

| | | Gelombang | | Malangga | | Pak nungkat | | Sekabuk | | Titi Dahan | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Parts used | All | 2 | (6.5%) | 3 | (13.6%) | 7 | (8.5%) | 2 | (16.7%) | 7 | (16.3%) |
| | Fruits | 0 | (0.0%) | 0 | (0.0%) | 3 | (3.7%) | 0 | (0.0%) | 2 | (4.7%) |
| | Leaves | 21 | (67.7%) | 12 | (54.5%) | 52 | (63.4%) | 5 | (41.7%) | 18 | (41.9%) |
| | Roots | 5 | (16.1%) | 7 | (31.8%) | 16 | (19.5%) | 5 | (41.7%) | 14 | (32.6%) |
| | Sap | 0 | (0.0%) | 0 | (0.0%) | 1 | (1.2%) | 0 | (0.0%) | 0 | (0.0%) |
| | Stems | 0 | (0.0%) | 0 | (0.0%) | 3 | (3.7%) | 0 | (0.0%) | 2 | (4.7%) |
| | Top | 3 | (9.7%) | 0 | (0.0%) | 0 | (0.0%) | 0 | (0.0%) | 0 | (0.0%) |
| | Total | 31 | (100.0%) | 22 | (100.0%) | 82 | (100.0%) | 12 | (100.0%) | 43 | (100.0%) |
| Preparation | Fresh | 27 | (87.1%) | 20 | (90.9%) | 80 | (97.6%) | 12 | (100.0%) | 41 | (97.6%) |
| | Dry | 3 | (9.7%) | 2 | (9.1%) | 0 | (0.0%) | 0 | (0.0%) | 1 | (2.4%) |
| | Heat | 1 | (3.2%) | 0 | (0.0%) | 1 | (1.2%) | 0 | (0.0%) | 0 | (0.0%) |
| | Burn | 0 | (0.0%) | 0 | (0.0%) | 1 | (1.2%) | 0 | (0.0%) | 0 | (0.0%) |
| | Total | 31 | (100.0%) | 22 | (100.0%) | 82 | (100.0%) | 12 | (100.0%) | 42 | (100.0%) |
| Application method | Decoction | 20 | (64.5%) | 15 | (68.2%) | 35 | (42.7%) | 8 | (66.7%) | 29 | (67.4%) |
| | Mash | 9 | (29.0%) | 4 | (18.2%) | 37 | (45.1%) | 3 | (25.0%) | 8 | (18.6%) |
| | Press | 1 | (3.2%) | 3 | (13.6%) | 4 | (4.9%) | 0 | (0.0%) | 5 | (11.6%) |
| | Directly | 1 | (3.2%) | 0 | (0.0%) | 6 | (7.3%) | 1 | (8.3%) | 1 | (2.3%) |
| | Total | 31 | (100.0%) | 22 | (100.0%) | 82 | (100.0%) | 12 | (100.0%) | 43 | (100.0%) |
| Application way | Internal | 24 | (77.4%) | 18 | (81.8%) | 46 | (56.1%) | 9 | (75.0%) | 34 | (79.1%) |
| | External | 7 | (22.6%) | 4 | (18.2%) | 36 | (43.9%) | 3 | (25.0%) | 9 | (20.9%) |
| | Total | 31 | (100.0%) | 22 | (100.0%) | 82 | (100.0%) | 12 | (100.0%) | 43 | (100.0%) |

Table 2. Frequency of plant parts used, preparation and application way for medicinal applications by each community of Sekabuk village.

| | | Gelombang | | Malangga | | Pak nungkat | | Sekabuk | | Titi Dahan | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Internal | External | Internal | External | Internal | External | Internal | External | Internal | External |
| Whole plant | Fresh | 2 | 0 | 3 | 0 | 6 | 1 | 1 | 1 | 4 | 2 |
| | Dry | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| | Heat | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Burn | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Fruits | Fresh | 0 | 0 | 0 | 0 | 2 | 1 | 0 | 0 | 2 | 0 |
| | Dry | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Heat | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Burn | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Leaves | Fresh | 10 | 7 | 9 | 2 | 22 | 28 | 4 | 1 | 13 | 5 |
| | Dry | 3 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Heat | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| | Burn | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| Roots | Fresh | 5 | 0 | 4 | 2 | 11 | 5 | 4 | 1 | 12 | 2 |
| | Dry | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Heat | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Burn | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sap | Fresh | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| | Dry | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Heat | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Burn | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Stems | Fresh | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 2 | 0 |
| | Dry | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Heat | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Burn | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Top | Fresh | 3 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Dry | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Heat | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Burn | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

### Used Plant Parts

The leaves were most frequently used (108), followed by roots (47), whole plant (21), top (6), stems and fruits (5), and sap (1) in Sekabuk village (Table 1). This is the similar result as reported in many other ethnomedicinal studies in Asia (Pahnyaphu *et al*. 2011; Kadir *et al*. 2012; Inta *et al*. 2013; Junsongduang *et al*. 2014; Kichu *et al*. 2015). The leaves are more easily harvested compared to the other parts and the harvesting process is less damaging to the health of the plant itself (Tetali *et al*. 2009). The second most commonly used parts are the roots, because local people preferred plants of Zingiberaceae family in this village. Additionally, roots contain high concentration of bioactive compounds related to their function as reservoir (Srithi *et al*. 2009).

### Preparation and Administration

The most common preparation method in Dayak communities (Gelombang, Malangga, Sekabuk and Titi Dahan) was taking as fresh (87.1~100.0%), followed by decoction (64.5~68.2%), mash (12.2~25.0%), press (0.0~13.6%), and directly (0.0~8.3%). Meanwhile, it is indicative that inhabitants in Pak nungkat used two methods at a similar rate; decoction (42.1%) and mash (45.1%) (Table 2).

The most frequently used administration routes in Dayak communities was internal (75.0~81.8%) rather than external (18.2~25.0%) in Table 2. Several studies have similar results (Giday *et al*. 2003; Rokaya *et al*. 2010; Kichu *et al*. 2015). In our study, the mode for internal application was ‘drink’ and ’eat’, while the external application was ‘gargle’, ‘paint’, ‘put’ and ‘squirt’.

In the case of administration, people in Pak nungkat had a different trend. Malay people had a similar rate in the mode of administration: internal (56.1%) and external (43.9%). Looking at the relationship between the used parts and administration (Table 2), Dayak communities used fresh leaves for internal administration (4~13) rather for than external (1~7). Malay community preferred fresh leaves for external (28) as well as for internal (22).

### Awareness of Medicinal Plants in each Community

Table 3 summarizes the medicinal plants that were recognized by more than 60% of inhabitants in each community. We analyzed the reorganization of medicinal plants commonly by focusing attention on community. In Sekabuk village, 11 species have been widely known.

Table 3. Awareness rate of medicinal plants that are well-recognized in each community.

| Gelombang | (%) | Pak nungkat | (%) | Sekabuk | (%) | Titi Dahan | (%) |
|---|---|---|---|---|---|---|---|
| *Rhodomyrtus tomentosa* Hassk. | 100 | *Kaempferia galanga* L. | 73 | *Leonurus sibiricus* L. | 92 | *Eurycoma longifolia* Jack | 91 |
| *Ageratum conyzoides*.L | 100 | *Kalanchoe pinnata* Pers. | 71 | *Orthosiphon aristatus* (Blume) Miq. | 88 | *Rhodomyrtus tomentosa* Hassk. | 83 |
| *Eurycoma longifolia* Jack | 100 | *Orthosiphon aristatus* (Blume) Miq. | 71 | *Zingiber officinale* Roscoe | 84 | *Leonurus sibiricus* L. | 80 |
| N/A | 100 | *Melastoma malabathricum* L. | 70 | *Eurycoma longifolia* Jack | 84 | *Ageratum conyzoides*.L | 77 |
| *Morinda citrifolia* L. | 80 | *Parkia sp* | 70 | *Rhodomyrtus tomentosa* Hassk. | 80 | *Orthosiphon aristatus* (Blume) Miq. | 77 |
| *Zingiber officinale* Roscoe | 80 | *Zingiber purpureum* Roscoe | 69 | *Psidium guajava* L. | 79 | *Piper betle* L. | 76 |
| *Psidium guajava* L. | 80 | *Piper betle* L. | 69 | *Imperata cylindrica* P.Deauv. | 79 | *Morinda citrifolia* L. | 75 |
| *Leonurus sibiricus* L. | 80 | *Syzygium polyanthum* Thwaites | 68 | *Kalanchoe pinnata* Pers. | 78 | *Psidium guajava* L. | 75 |
| *Styrax sp* | 80 | *Morinda citrifolia* L. | 66 | *Morinda citrifolia* L. | 76 | *Paederia foetida* L. | 74 |
| *Ricinus communis* L. | 80 | *Alpinia galanga* Willd. | 65 | *Alpinia galanga* Willd. | 75 | *Imperata cylindrica* P.Deauv. | 74 |
| *Orthosiphon aristatus* (Blume) Miq. | 80 | *Hibiscus rosa-sinensis* L. | 65 | *Aglaonema nitidum* Kunth | 75 | *Cassia alata* L. | 74 |
| *Centella asiatica* Urb. | 80 | *Ageratum conyzoides*.L | 64 | *Piper betle* L. | 75 | *Ricinus communis* L. | 74 |
| *Ocimum basilicum* L. | 80 | *Syzygium aqueum* Alston | 63 | *Elephantopus scaber* L. | 74 | *Aglaonema nitidum* Kunth | 73 |
| *Dillenia excelsa* Martelli | 80 | *Physalis angulata* L. | 63 | *Ageratum conyzoides*.L | 74 | *Melastoma malabathricum* L. | 72 |
| *Callicarpa longifolia* Lam. | 80 | *Psidium guajava* L. | 63 | *Paederia foetida* L. | 71 | *Cheilocostus speciosus* (J.Koenig) C.D.Specht | 72 |
| *Kaempferia galanga* L. | 60 | *Zingiber officinale* Roscoe | 62 | *Cassia alata* L. | 71 | *Zingiber officinale* Roscoe | 71 |
| *Euphorbia thymifolia* L. | 60 | *Euphorbia thymifolia* L. | 61 | *Ricinus communis* L. | 71 | *Styrax sp* | 71 |
| *Physalis angulata* L. | 60 | *Curcuma xanthorrhiza* D.Dietr. | 61 | *Annona muricata* L. | 71 | *Ocimum basilicum* L. | 70 |
| *Elephantopus scaber* L. | 60 | *Ricinus communis* L. | 61 | *Kaempferia galanga* L. | 68 | *Syzygium polyanthum* Thwaites | 69 |
| *Parkia sp* | 60 | *Coffea sp* | 61 | *Ocimum basilicum* L. | 67 | *Annona muricata* L. | 68 |
| *Paederia foetida* L. | 60 | *Momordica charantia* L. | 61 | *Melastoma malabathricum* L. | 64 | *Callicarpa longifolia* Lam. | 67 |
| *Vitex negundo* L. | 60 | | | *Parkia sp* | 64 | *Vitex negundo* L. | 66 |
| *Alpinia galanga* Willd. | 60 | | | *Syzygium polyanthum* Thwaites | 64 | *Kaempferia galanga* L. | 64 |
| *Carica papaya* L. | 60 | | | *Vitex negundo* L. | 63 | *Alpinia galanga* Willd. | 64 |
| *Syzygium polyanthum* Thwaites | 60 | | | *Justicia gendarussa* Brum.f. | 61 | *Momordica charantia* L. | 64 |
| *Piper betle* L. | 60 | | | N/A | 61 | *Kalanchoe pinnata* Pers. | 63 |
| *Annona muricata* L. | 60 | | | *Cheilocostus speciosus* (J.Koenig) C.D.Specht | 61 | N/A | 63 |
| *Cheilocostus speciosus* (J.Koenig) C.D.Specht | 60 | | | | | *Parkia sp* | 61 |
| *Saccharum sp* | 60 | | | | | | |
| *Curcuma xanthorrhiza* D.Dietr. | 60 | | | | | | |
| *Flagellaria indica* L. | 60 | | | | | | |

Among them, eight species were popular as medicinal plants throughout Indonesia; *Alpinia galanga* Willd., *Kaempferia galanga* L., *Orthosiphon aristatus* (Blume) Miq., *Morinda citrifolia* L., *Piper betle* L., *Psidium guajava* L., *Syzygium aqueum* Alston, and *Zingiber officinale* Roscoe (Bahari 2013; Ningrum and Murtie 2013). Nine species were well known in Dayak communities, Gelombang, Sekabuk and Titi Dahan. *Leonurus sibiricus* L., called 'Kacang mah' was recognized among Dayak people by 80%, while Malay people rarely know this plant name nor the usage as medicine. Dayak said this local name is from the Chinese language and it is widespread in Dayak community because many Dayaknese have married Chinese people. Four medicinal plants were reported to be frequently used only in Pak nungkat. We discovered that these plants have been in the Malay people for generations. Three communities other than Gelombang used two of the same plants for medicine. Only in Gelombang, the five plants were highly recognized, but it cannot be concluded that these five plants are used primarily in Gelombang as medicinal plants because we were only able to interview five people in Gelombang. Among the two plants that were frequently used in the three communities besides Gelombang, *Melastoma malabathricum* L. has been previously researched as a plant that has been used among Gelombang and has also been highly recognized in Sekabuk village. The other plant, *Kalanchoe pinnata* Pers. has been cultivated in every community except Gelombang.

We summarized plant families in which plants have an awareness rate of 60% or more in Table 4. It was clearly that Dayak communities have unique tendency. Gelombang, Sekabuk and Titi Dahan most prefer to use Lamiaceae family, followed by Zingiberraceae and Myrtaceae. Meanwhile in Pak nungakt, Malay community zingiberaceous plants are used frequently as medicinal plants. Although Myrtaceae also was mentioned as well as other communities, one spicies belongs to Lamiaceae. In part of 'Characteristics of medicinal plants', it was showed that Zingiberaceae are very widespread in Southeast Asia. Myrtaceous plants are also distributed throughout the tropics, with concentration in Southeast Asia. Many species are cultivated in home gardens to use many economically important food plants, agricultural crops and medicinal plants (Reynertson *et al*. 2008). The only plants mentioned in common to Sekabuk village of the Lamiaceae, *Orthosiphon aristatus* (Blume) Miq. is very famous as medicinal plants in Indonesia. Two species out of lamiaceous plants mentioned in Dayak communities: *Leonurus sibiricus* L. and *Vitex negundo* L. are named by using Chinese language. These plants might be transmitted from Chinese people which live in this village. Although *Vitex negundo* L. was known as medicinal plant in Pak nungkat, *Leonurus sibiricus* L. was relatively unknown. Preparation of this plant as remedy was made using rice wine. Therefore, it is clear that it has not penetrated the ethnic not allowed to drink alcohol as medicinal plant.

Table 4. The top three family of plants that are often used in each community

| Gelombang | | Pak nungkat | | Sekabuk | | Titi Dahan | |
|---|---|---|---|---|---|---|---|
| Lamiaceae | 5 | Zingiberaceae | 5 | Lamiaceae | 4 | Lamiaceae | 5 |
| Zingiberaceae | 4 | Myrtaceae | 3 | Zingiberaceae | 3 | Zingiberaceae | 3 |
| Myrtaceae | 3 | | | Myrtaceae | 3 | Myrtaceae | 3 |

**Gender of Medicinal Plants Knowledge**

There was no significant difference between the awareness rate of medicinal plant and the gender, males and females (*t*-test, $P = 0.729$). In general, women were more knowledgeable about medicinal plants than men (Caniago and Siebert 1998; Pahnyaphu *et al*. 2011; Almeida *et al*. 2012; Junsongduang *et al*. 2014). Whereas gender reflects the fact that women tend to be more responsible for family, especially child health care (Caniago and Siebert 1998; Almeida *et al*. 2012; Albuquerque *et al*. 2011) stated that men mentioned more ethnospecies than women did. This ethnic group trended that man collected the medicinal plants from the forest, and when a woman desired a medicinal plant from these areas, she would find a man to collect it. Additionally, their study observed that the anthropogenic areas were the women's main collection sites. In our study, there was no significant difference in collection sites (Table 5). Sekabuk villagers most commonly collected medicinal plants around their house; male (84.9%), female (80.5%). We observed that most of inhabitants earned their living through rice agriculture. In addition, they harvested rubber from trees and also logging wood as their side job.It seems that there is a culture that both men and women work inside and outside the house. Therefore, the knowledge and collection sites of both gender have no significant difference.

Table 5. Collection sites of medicinal plants by each gender in Sekabuk village

| Collection sites | % of collection | |
|---|---|---|
| | Men | Women |
| In the village | 84.9 | 80.5 |
| Mountain | 2.7 | 4.2 |
| Forest | 8.2 | 7.6 |
| Rice filed | 1.4 | 2.5 |
| Other | 2.7 | 0.0 |

## Conclusions

To conclude, in Sekabuk village, Sadaniang Sub-district, Mempawah District in West Kalimantan, Indonesia, 66 plants were used as medicine. The plants used as medicine were clearly different by ethnic groups, that is Malay and Dayak. Local names of the plants were also different in ethnic groups. Therefore, their knowledge is clearly traditional. Additionally, the living environments effect the difference of used plants due to easiness to obtain plants. Some plants were used in common by each groups. They are widely known in Indonesia, so that this knowledge probably come through media such as books. We will continue the quantitative analysis of the data and will clarify detailed characteristics of medicinal plant usage in this village.

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Appendix 1. Medicinal Plant Used in Sekabuk Village Mempawah District West Kalimantan Indonesia

| No. | Scientific name | Family | Local name | | No. of use-reports | Diseases | Parts used | How to Use |
|---|---|---|---|---|---|---|---|---|
| | | | Malay | Dayak | | | | |
| 1 | *Ageratum conyzoides* L. | Asteraceae | kelemaok | Panjat (pancat) kambing | 17 | Stomachache; cold; heat | Lf | Drink |
| | | | | | | Stomachache; fever | Rt | Drink |
| 2 | *Aglaonema nitidum* Kunth | Araceae | peetan | limpeet | 1 | Fever | Rt | Drink |
| 3 | *Alpinia galanga* Willd. | Zingiberaceae | lengkuas | lengkong | 2 | Skin fungus; afterbirth | Rt | Put |
| 4 | *Annona muricata* L. | Annonaceae | sirsak/nangka belanda | sirsak/nangka belanda | 7 | Heat; high fever; fever; goiter; hypertension | Lf | Drink |
| | | | | | | Headache | Lf | Put |
| 5 | *Archidendron clypearia* (jack) I.C.Nielsen | Leguminosae | kedengkang | tatampak | 2 | Malaria | Rt | Drink |
| 6 | *Bauhinia sp* | Fabaceae | tapak kuda | bameak | 3 | Strangury | Lf | Drink |
| | | | | | | Heat | Rt; Lf+Rt | Drink |
| 7 | *Callicarpa longifolia* Lam. | Lamiaceae | tampar besi | tamar basi | 11 | High fever; headache | Lf | Put; Squirt |
| 8 | *Carica papaya* L. | Caricaceae | papaya/kates | papaya | 1 | Malaria | Lf | Drink |
| 9 | *Cassia alata* L. | Leguminosae | ketepeng | lingam | 2 | Skin fungus | Lf | Paint |
| | | | | | | Coastipation | Rt | Drink |
| 10 | *Centella asiatica* Urb. | Apiaceae | pegage | pegaga | 3 | Malaria; tiredness(child); cough | Lf | Drink |
| 11 | *Cheilocostus speciosus* (J.Koenig) C.D.Specht | Costaceae | tabu lego | tabu lego | 3 | Vaginal discharge | Lf | Drink; wash |
| 12 | *Coffea sp* | Rubiaceae | kopi | kopi | 1 | Hypertension | Lf | Drink |
| 13 | *Cordyline fruticosa* Göpp. | Agavaceae | renjuang | rinyuang | 1 | Blood feves | Lf | Drink |
| 14 | *Curcuma heyneana* Valeton & Zijip | Zingiberaceae | kunyit putih | kunyit putih | 1 | Anemia | Rt | Drink |
| 15 | *Curcuma xanthorrhiza* D.Dietr. | Zingiberaceae | temulawak | | 2 | Gastric | Rt | Drink |
| 16 | *Dillenia excelsa* Martelli | Dilleniaceae | simpur | abuant | 1 | Injury(blood) | Lf | Put |
| 17 | *Elephantopus scaber* L. | Asteraceae | tutup bumi | camteo | 4 | Heat; malaria | Lf; Rt | Drink |
| | | | | | | Vaginal discharge | Al | Drink |
| 18 | *Euphorbia thymifolia* L. | Euphorbiaceae | - | cumanen/kerak nasi | 3 | Toothache; fever | Al | Drink |
| | | | | | | Swelling | Lf | Put |
| 19 | *Eurycoma longifolia* Jack | Simaroubaceae | pasak bumi/bidara | pasak bumi/bidara | 8 | Stomachache; pain; cold; itch | Rt; St | Drink |
| 20 | *Excoecaria chochinchinensis* Lour. | Euphorbiaceae | | balik merah | 1 | Insect bites | Lf | Paint |
| 21 | *Flagellaria indica* L. | Flagellariaceae | rotan bini | uwidodok | 2 | Fever; malaria | Rt | Drink |
| 22 | *Gnetum gnemon* L. | Gnetaceae | dudamak | dadamak | 1 | Toothache | Rt | Drink |
| 23 | *Hibiscus rosa-sinensis* L. | Malvaceae | gambak | kembang sepatu | 2 | Headache | Lf | Paint |
| | | | | | | Strangury | Rt | Drink |
| 24 | *Imperata cylindrica* P.Deauv. | Poaceae | lalang/alang alang | lalang/padang | 3 | Fever | Rt | Drink |
| 25 | *Justicia gendarussa* Brum.f. | Acanthaceae | gandarusa | gandarusa | 1 | Broken bone | Lf | Put |
| 26 | *Kaempferia galanga* L. | Zingiberaceae | cekur | cakur | 2 | Full stomach; gastric | Lf; Rt | Squirt |
| 27 | *Kalanchoe pinnata* Pers. | Crassulaceae | daun tumbuh didaun | pandingin | 5 | Fever; toothache; headache | Lf | Put |
| 28 | *Leonurus sibiricus* L. | Lamiaceae | - | kacang mah | 7 | Broken bone | Rt | Drink; paint |
| | | | | | | Cold; afterbirth; pain; fever | Lf | Drink |
| 29 | *Lygodium microphyllum* (Cav) R.Br. | Schizaeaceae | ribu ribu | | 6 | Fever; painful; stomatitis | Lf | Drink; put |
| | | | | | | Heat | Rt+Lf | Drink |
| 30 | *Melastoma malabathricum* L. | Melastomataceae | cengkodok | lingkodok | 3 | Toothache; strangury | Lf | Drink |
| | | | | | | Diarrhea | Rt | Drink |
| 31 | *Momordica charantia* L. | Cucurbitaceae | periak | kuria | 2 | Chickenpox; fever | Lf | Paint |
| 32 | *Morinda citrifolia* L. | Rubiaceae | cengkudu | lingkudu | 3 | Hypertension | Fw | Drink; eat |
| 33 | *Ocimum basilicum* L. | Lamiaceae | selaseh | selaseh | 3 | Fever; cold; full stomach | Lf | Drink |
| 34 | *Oldenlandia corymbosa* L. | Phyllanthaceae | | | | | | |
| 35 | *Orthosiphon aristatus* (Blume) Miq. | Lamiaceae | kumis kucing | kumis kucing | 9 | Toothache | Rt | Put |
| | | | | | | Strangury | Lf; | Drink |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | Lf+Rt | |
| | | | | | | Malaria | Lf | Drink |
| 36 | *Paederia foetida* L. | Rubiaceae | seguntut | kakantut | 3 | Feeling of fullness | Lf | Eat |
| 37 | *Panax ginseng* C.A.Mey. | Araliaceae | ginseng | | 2 | Stamina; painful | Rt; Lf | Drink |
| 38 | *Pandanus amaryllifolius* Roxb. | Pandanaceae | pandan | pandan | 1 | Hypertension | Lf | Drink |
| 39 | *Parkia sp* | Fabaceae | kedaong | kadaong | 1 | Full stomach | Sd | Squirt |
| 40 | *Passiflora foetida* L. | Rubiaceae | leletop | songban | 4 | Toothache | Rt | Gargle |
| | | | | | | Stomachache | Lf | Drink; put |
| 41 | *Phyllanthus urinaria* L. | Euphorbiaceae | ambin buah | - | 1 | Fever, heat | Al | Drink |
| 42 | *Physalis angulata* L. | Solanaceae | | gaguntur | 3 | Diabetes; hypertension; heat | Rt+St; Rt; Rt+Lf | Drink |
| 43 | *Piper betle* L. | Piperaceae | sirih | karakek | 7 | Feeling of fullness; fever | Lf | Paint |
| 44 | *Pithecellobium jiringa* (Jack) Prain | Leguminosae | jengkol | jengkol | 3 | Diarrhea(child); pain(baby); fever | Lf | Drink |
| 45 | *Psidium guajava* L. | Myrtaceae | jambu batu | jambu karasik | 9 | Stomachache; diarrhea | Lf | Drink |
| | | | | | | Dengue | Fw | Eat |
| 46 | *Rhodomyrtus tomentosa* Hassk. | Myrtaceae | karimunting | karimunting | 5 | Stomachache | Rt+Lf | Drink |
| | | | | | | Diarrhea(child); pain(baby); fever; stomatitis | Rt | Drink |
| 47 | *Ricinus communis* L. | Euphorbiaceae | jarak merah | korongan | 5 | Broken bone; | Lf | Put |
| | | | | | | Swelling; menstrution | Lf+Rt | Put; drink |
| | | | | | | Vaginal discharge | Rt | Drink |
| 48 | *Saccharum sp* | Poaceae/Graminea e | tebu selasih | | 2 | Phlegm; headache | St | Drink |
| 49 | *Sericocalyx crispus* (L.) Bremek. | Acanthaceae | | kejibling | 1 | Kidney | Lf | Drink |
| 50 | *Sida acuta* Burm.f. | Malvaceae | penyapu cina | panipo | 5 | Stomachache; strangury; toothache | Lf | Drink |
| 51 | *Styrax sp* | Styracaceae | kemenyan | kemenyan | 2 | Stomachache | St | Drink |
| 52 | *Syzygium aqueum* Alston | Myrtaceae | jambu bereteh | | 3 | Meales; smallpox; ulcer | Lf | Paint |
| 53 | *Syzygium aromaticum* (L.) Merr. & L.M.perry | Myrtaceae | cengkeh | cengkeh | 2 | Toothache | Fb | Put |
| 54 | *Syzygium polyanthum* Thwaites | Myrtaceae | salam | ubah ubeh | 5 | Stomatitis | Lf | Eat |
| | | | | | | Stomatitis; diarrhea(child); pain(baby); fever | Rt | Drink |
| 55 | *Vitex negundo* L. | Lamiaceae | laban tong san | laban tong san | 4 | Gastric; fever; cold; full stomach | Lf | Drink |
| 56 | *Vitex pinnata* L. | Lamiaceae | leban | leban | 5 | Gastric; broken bone | Lf | Squirt |
| | | | | | | Heat; asthma | Lf | Drink |
| 57 | *Vitex trifolia* L. | Lamiaceae | gelegundi | - | 3 | Headache | Lf | Put; paint |
| | | | | | | Acne | Lf | Drink |
| 58 | *Zingiber officinale* Roscoe | Zingiberaceae | jahe/liak | jahe/liak | 8 | Sprain of legs; afterbirth; painful; stomachache | Rt | Put; eat; drink |
| 59 | *Zingiber purpureum* Roscoe | Zingiberaceae | banglai | banglai | 4 | Cold; pain; afterbirth | Rt | Drink; put |
| 60 | *Zingiber zerumbet* (L.) Sm. | Zingiberaceae | lempuyang | saringkuyang | 3 | Fever; gastric; afterbirth | Rt | Drink |
| 61 | | Euphorbiaceae | menggalai taun | manggala | 2 | Asthma | Lf | Squirt |
| | | | | | | Animal biting | Sp | Paint |
| 62 | Unidentified | Amyrillidaceae | bakum | sare manamu | 3 | Pain; sprain of legs | Rt | Put |
| 63 | Unidentified | Asteraceae | - | tainge | 6 | Fever; cold; full stomach | Lf | Drink |
| | | | | | | Anemia; headache | Lf+St | Drink |
| 64 | Unidentified | Urticaceae | budae | dagar | 4 | Burn injury | Lf | Paint |
| | | | | | | Fever; stomachache | Lf | Put |
| 65 | N/A | | | rautan | 3 | Fever; cold; full stomach | Lf | Drink |
| 66 | N/A | | | tabaang | 1 | Cold | Lf | Drink |

Al = all; Lf = leaves; Rt = roots; Fw = flowers; Fb = flower buds; Sp = sap; St = stem; Sd = seed

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# WOOD RESEARCH Journal

## Journal of Indonesian Wood Research Society

### Annals of the Wood Research Journal

Wood Research Journal is the official journal of the Indonesian Wood Research Society. This journal is an international medium in exchanging, sharing and discussing the science and technology of wood.

### Aims and Scope

The journal publishes original manuscripts of basic and applied research of wood science and technology related to Anatomy, Properties, Quality Enhancement, Machining, Engineering and Constructions, Panel and Composites, Entomology and Preservation, Chemistry, Non Wood Forest Products, Pulp and Papers, Biomass Energy, and Biotechnology. Besides that, this journal also publishes review manuscripts which topics are decided by the Editors.

### Imprint

WRJ is published by Indonesian Wood Research Society
**ISSN print: 2087-3840**
Electronic edition is available at:
**http://ejournalmapeki.org/index.php/wrj**

### Publication Frequency

Journal is published in one volume of two issues per year (April and October).

### Peer Review Policy

WRJ reviewing policies are: Every submitted paper will be reviewed by at least two peer reviewers. Reviewing process will consider novelty, objectivity, method, scientific impact, conclusion and references.

### General Remarks

Manuscripts will be accepted for publications are those discussing and containing results of research on wood science and technology, and reviews on specific topics, which are decided by the Editors and have not been published elsewhere. Authors are requested to correct the manuscripts accepted for publications as suggested by the Reviewers. Editors could change positions of Figures and Tables.

### Manuscripts Preparations

1. Manuscripts must be in English, typewritten using Word, Arial Narrow, single space, 3 cm of left and right margin and 2.5 cm of top and bottom margin of a Letter paper size. Title is printed with a font size of 14 pt, Authors are of 12 pt, and Text is of 10 pt.
2. Manuscripts should be checked for spelling and grammar by a native speaker.
3. Manuscripts compositions:

3.1. Title
3.2. Complete name of Authors
3.3. Abstract
3.4. Key words
3.5. Texts:
Introduction
Materials and Methods Results and Discussion
Conclusions (and Suggestions) References
Name and complete address of Authors
Appendix

4.Other rules:

4.1. Names of wood are followed by Botanical Name.
4.2. Values between are written using this symbol (~), e.g. 3.75 ~ 8.92%.
4.3. Editors could modify Figures without changing their substantial meaning.
4.4. References are arranged from A to Z.
4.5. References in text are written as this example: (Palomar *et al.* 1990; Arancon 1997).
4.6. Examples of writing of References: Altschul, S.F.; T.L. Madden; A.A. Schäffer; J. Zhang; Z. Zhang; W. Miller; D.J. Lipman. 1997. Gapped BLAST and PSI-BLAST: A New Generation of Protein Database Search Programs. Nucleic Acids Res. 25: 3389-3402.

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**Example of Table and Figure**

Table 1. Effects of temperature on *in vitro* growth of seedlings.

| Temp. (°C) | Shoot length (mm) | Number of leaf | Fresh weight (g) |
|---|---|---|---|
| 25 | 59.2 ± 10.6[c] | 4.5 ± 0.8[a] | 0.29 ± 0.13[a] |
| 27 | 88.5 ± 9.3[a] | 4.8 ± 0.9[a] | 0.40 ± 0.12[a] |
| 29 | 75.0 ± 11.1[b] | 3.8 ± 0.6[a] | 0.30 ± 0.07[a] |

Note: Values (average ± standard deviation) with different letters are statistically significant according to Tukey's multiple comparison test. Data were recorded after 4 weeks of culture. MS medium was used as a basal medium without any PGRs. Number of sample = 10.

Source: Chujo *et al.* 2010.

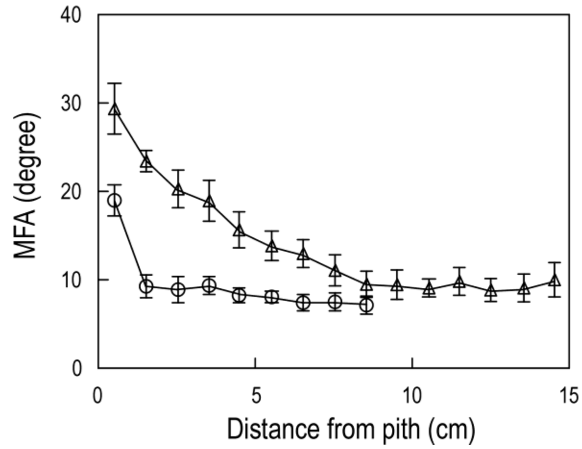


Figure 3. Radial variation of microfibril angle of the S2 layer in tracheid. Open circle, *Agathis* sp.; open triangle, *Pinus insularis*; Bars indicate the standard deviation. (Source: Ishiguri *et al.* 2010)

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