6. その他の性質
Other Properties

6.1 Hardness of Sulawesi Woods

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スラウェシー産材のかたさ特性

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6.1.1 Introduction

Hardness is one of the important physical properties of wood, since it depends mainly on the amount of the cell wall present. Kollmann (1968) defined hardness as the resistance of a solid body against the penetration of another solid body by force. The hardness of wood increases as it loses moisture below the fiber saturation point. The end hardness of hardwoods increases approximately 50 percent as they dry from the green condition to a moisture content of 12 percent [Panshin (1970)].

Egusa (1968) found that wood hardness on the tangential surface could be used as a useful indicator in determining whether a species is easy or difficult to be peeled. He also found that the difficulties in peeling a log of some species could be reduced by boiling or steaming the wood. According to Bodig & Jayne (1982) hardness is a particularly important property factor to evaluate species used for flooring, furniture and other uses in which a good wearing surface is desirable.

Woods of the tropical forests are extremely numerous in species and varied in property. Although it has been recognized that recently tropical woods played a key role in supplying the demand of wood in the world, the properties and uses of many of its species are still unknown.

Based on the above illustration and the fact that hardness test is simple and easy to do, then an investigation on the hardness of Togian wood species, Sulawesi, Indonesia, as a study in determining the uses of those woods was considered as a necessary work to do.

Of the various methods for determining hardness of a given wood, Brinell-hardness test is considered as a suitable one. A strong correlation between Brinell-hardness H_B and tensile strength σ_{tB} ($\sigma_{tB} \approx 0.33$ to $0.36\ H_B$ kp/mm^2) had been shown by Kollmann (1968). Mayer-Wegelin as quoted by Parameswaran (1978) had reported a relationship between needle hardness and Brinell-hardness for wood: the incision depth increased rapidly with decreasing Brinell-hardness. They also reported that the Brinell-hardness reflects more or less the compressive strength.

As many as fourty-one Togian wood species had been tested with Brinell-hardness tester. The object of this study was to find out whether there was any consistent pattern of variation in hardness from pith to bark, and to find out the effect of wood condition on its hardness which will be used as a reference in determining which condition is suitable to be applied in peeling a given wood.

6.1.2 Material and Experimental Procedures

All of the tests in this study were carried out in the Department of Forest Products, Faculty

of Agriculture, Nagoya University. Specimens were prepared in the Wood Workshop of the Department of Forest Products, whereas measurements of the dimensions and weight of each specimen and also hardness test were carried out in the Wood Physics Laboratory.

(1) Material

Tests were made using fourty-one tropical wood species. They were obtained from Togian island, Indonesia. Appendices 1 & 2 list all of the species used in this study. All of the fourty-one species, each was represented by one log.

Based on the manner the specimens were taken, specimens used in this study were classified into two groups. Group one was the group of specimens taken randomly from the area between pith and bark of each log. Logs of those specimens were obtained from shipment number five and six.

Group two consisted of specimens obtained from shipment number seven. A disk with the minimum thickness of 4 cm was removed from each log of this group. Depended on the diameter of the tree then four or five specimens along different radii (from pith to bark) of the same line were taken out from each disk. Two of them were taken out from a definite area of the disk that were one specimen from the area near the pith and the other one from the area near the bark. The remaining two to three specimens were taken out from the area between those two specimens mentioned earlier. It was intended to get a feature of the distribution of hardness in those woods. Specimens of both groups were free of any visible defects. Selected material was then machined into standard specimen size of 4 cm by 4 cm by 4 cm. Method of taking a specimen is as seen in Fig. 1.

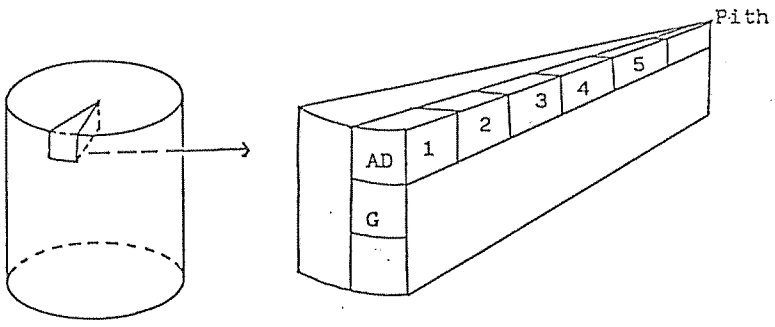

Fig. 1. Sketch showing method of taking the specimens.

Notes:
AD: Specimen of air dry condition
G: Specimen of green condition
1-5: Replications

(2) **Testing Method.**

(a) **Testing Condition.**

Specimens belong to group one (I) were collected from twenty-two logs where hardness was only measured in two specimen condition i.e. green and boiled condition. The purpose of the hardness measurement in this group was only to determine whether tested species would be easy or difficult to be peeled.

Of the six specimen's surfaces, three surfaces consisted of end, tangential and radial surface were used for measuring its hardness in green condition. The other three surfaces which also consisted of end, tangential and radial surface were used for measuring its hardness in boiled condition. In this group, wood hardness had been measured only on one point of each surface.

Green condition test was carried out before its specimens were either dried or given any treatment. After hardness of green condition specimens were measured then all of those specimens were boiled in the 100°C water for four hours. After boiling treatment then they were soaked in water of room temperature before testing.

Specimens of group II came from nineteen logs. Green, boiled and air dry specimen condition were used in this test. Here, green condition test specimens were also used for testing in the boiled condition as it had been done in the previous group. Specimens for the air dry test were different from those of the green condition test. Air dry specimens were taken from a different part of the same disk. Specimens for air dry test were first dried until they reached a moisture content of about 12% and then they were used for testing. Nine different points of end surface and six different points of tangential as well as radial surface were used for measuring hardness of all specimens from group II. Brinell hardness test in accordance with JIS Z 2117 were carried out for all specimens of this group.

The dimensions and the form of the specimen for hardness test are presented in Fig. 2.

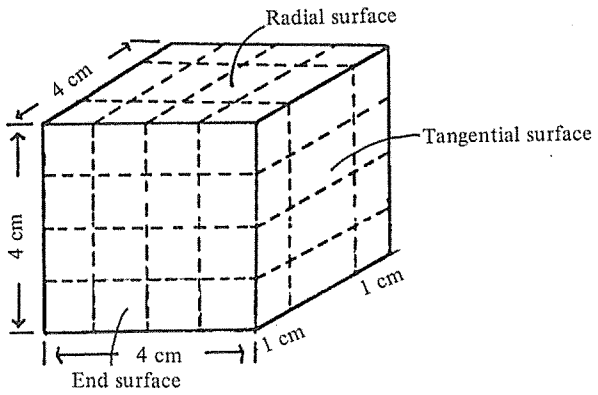

Fig. 2. The dimensions and the form of the specimen.

(b) **Hardness Test.**

Specimen 4 cm by 4 cm by 4 cm was then placed on the Brinell-hardness tester of the Akashi Seisakusho. Load capacity of this tester is 100 kg and the rate of penetration of the steel ball is about 0.5 mm per minute.

The load required to force a steel ball indentator of 10 mm diameter into a measurement point of the test piece to a depth of 0.32 mm was then recorded in kilogram and was used for calculating hardness of the corresponding specimen. In the case that the steel ball of the tester could not be embedded into a specimen depth of 0.32 mm then measurement for such kind of specimen was based on the depth of the steel ball indentation which could be reached by 100 kg load.

(3) Specific Gravity.

Specific gravity is expressed as air dry specific gravity i.e. volume in air dry condition and weight in air dry condition too.

(4) Method of Calculation.

Data obtained from the hardness tests were then used for calculating its hardness. The hardness value is calculated by the following equation [Sawada et al. (1955)].

$$H = \frac{P}{\Pi.D.h} \qquad (1)$$

where:

H = hardness value (kg/mm^2).

D = Diameter of the steel ball (mm).

h = Embedded depth of the steel ball into wood (mm).

P = Load required to embed the steel ball (kg)

in this testing D = 10 mm; h = $1/\Pi$ mm = 0.32 mm hence equation (1) becomes:

$$H = \frac{P}{10} \qquad (2)$$

6.1.3 Results & Discussion

Hardness values for three different surfaces and other detail data obtained in this investigation are presented in the Appendix.

(1) Specific Gravity

Specific gravity measurement had only been done on specimens of group II. Average specific gravity of those nineteen species belong to group II were in the range of 0.29 in *Artocarpus sp.* to 1.08 in *Madhuca sp.* Average specific gravity of each species is as seen in Table 5.

(2) Hardness & Specific Gravity

Artocarpus sp. which had the lowest specific gravity shown the hardness of 2.79, 0.68 and 0.54 on end, tangential and radial surface respectively, whereas *Madhuca sp.* which had the highest specific gravity shown the hardness of 13.17, 7.77 and 5.31 on end, tangential and radial surface respectively.

Calculations on the data collected in this study produced several equations for the relationships between specific gravity and hardness on three different surfaces and three different specimen condition as shown in Table 1.

Equations in Table 1 indicate that there are good relationships between specific gravity and hardness of wood on any of its surfaces as well as specimen condition. Equations for end surface give the highest correlation coefficient than those two other surfaces. End surface gives values of 0.92, 0.96 and 0.93 correlation coefficient for green, air dried and boiled condition, respectively. Although equations for tangential and radial surfaces show a lower correlation coefficient than those of end surface, the values still indicate that strong relationships between specific gravity and hardness are still exist as can be observed in Table 1. Figure 3 shows the dependence of hardness in specific gravity on three different surfaces and three different specimen conditions. There is a general indication that for any of the testing (specimen) condition, end surface gives the highest hardness value than the other two surfaces. It is also noted that high specific gravity species also had high hardness value.

From Figure 3 it is also clear that the highest hardness value is on the end surface while the lowest is on the radial surface. Among three different testing conditions, wood with the air dry condition has the highest hardness value. It seems that on the radial surface, boiling treatment has only reduced hardness value of the wood with the specific gravity of less than 0.6. For the other two surfaces (end & tangential) boiling treatment always reduce their hardness.

(3) Hardness Ratio

Table 2 summarized ratio of the tangential and end surface to radial surface hardness in three different testing conditions and in general as the average of the three testing (specimen) conditions.

Radial surface has been used as a standard for this comparison solely because of the fact that in general hardness of this surface is the smallest. End to radial surface ratio shows a higher value than tangential to radial surface ratio as shown in Table 2 and also indicated by the graphs in Fig. 3.

Table 2 also shown that variation in the ratio of end to radial surface is bigger than that of tangential to radial surface. This is clearly shown in Table 2 that the smallest difference of the ratio of end surface is 0.28 that is the difference between ratio in green and boiled condition, while the biggest difference of the ratio of tangential surface is 0.12 that is the difference between ratio in green and air dry condition.

Based on the graph in Fig. 3 and ratio in Table 2 then it can be concluded that hardness value on end surface is not only the highest but the differences with the two other surfaces are also big. Furthermore an equation of $Y = -3.72\,X + 6.10$ with $r = 0.71$ shows that the bigger the specific gravity of a given wood, the lower the value of end to radial ratio as illustrated in Figure 4.

(4) Boiling & Air Drying Effect.

As mentioned before, hardness value for specimens from group I is only used for determining whether a species is easy or difficult to be peeled and for observing the effect of boiling treatment on its hardness. Therefore for this group, only two testing (specimen) conditions i.e. green and boiled conditions, which are supposed to be a suitable condition in peeling a kind of log, were used. The results in Appendix 3 reveal that in some species boiling treatment reduced their hardness, while in some other species this treatment increased the value of their hardness. A different manner and Table are also used for the presentation of the results from group I and

Table 1. Equations for the Relationships between Hardness and Specific Gravity in Three Different Surfaces and Three Different Conditions for Togian Wood Species.

End Surface		
Green	$Y = 7.81 x - 0.98$	$r = 0.92$
Air-dried	$Y = 13.37 x - 1.13$	$r = 0.96$
Boiled	$Y = 7.12 x - 0.99$	$r = 0.93$
Tangential Surface		
Green	$Y = 5.06 x - 1.48$	$r = 0.88$
Air-dried	$Y = 7.85 x - 2.13$	$r = 0.92$
Boiled	$Y = 4.65 x - 1.31$	$r = 0.89$
Radial Surface		
Green	$Y = 3.84 x - 1.01$	$r = 0.87$
Air-dried	$Y = 5.63 x - 1.36$	$r = 0.93$
Boiled	$Y = 4.32 x - 1.31$	$r = 0.91$

Notes:
Boiled : Specimens were boiled in 100°C water for four hours and soaked into water in room-temperature before testing.
r : Coefficient correlation.
Y : Hardness value.
x : Specific gravity.

Table 2. Ratio of the Tangential and End Surface Hardness to Radial Surface Hardness in Three Different Testing Conditions and in General.

Wood Condition	Surface		
	Radial	Tangential	End
Green	1	1.20	3.41
Air Dried	1	1.32	4.03
Boiled	1	1.21	3.13
General	1	1.24	3.54

Note:
Boiled: Specimens were boiled in 100°C water for four hours and soaked into water in room-temperature before testing.

Table 3. Ratio of Air Dried and Boiled Wood Hardness to Green Wood Hardness on Three Different Surfaces and in General.

Surface	Wood Condition		
	Green	Air Dried	Boiled
End	1	1.82	0.89
Tangential	1	1.71	0.95
Radial	1	1.57	1.01
General	1	1.70	0.95

Note:
Boiled: Specimens were boiled in 100°C water for four hours and soaked into water in room-temperature before testing.

Table 4. Classification of Nineteen Togian Wood Species Based on Hardness Pattern from Pith to Bark in Tangential Surface.

Pattern/Wood Species	Specific Gravity	Hardness** (kg/mm^2)
Pattern 1.		
Terminalia	0.69	4.02
Octomeles	0.38	1.04
Pattern 2.		
Koordersiodendron	0.72	2.54
Canarium	0.57	1.97
Palaquium	0.60	2.33
Pattern 3.		
Litsea	0.45	1.61
*Myristicaceae**	0.49	1.68
Eugenia	0.75	2.63
Madhuca	1.08	7.77
Ailanthus	0.46	1.59
Pattern 4.		
Gonystylus	0.58	2.22
Podocarpus	0.51	2.31
Heritiera	0.57	2.32
Pattern 5.		
Lophopetalum	0.47	1.73
Calophyllum	0.51	1.92
Dysoxylum	0.54	1.95
Artocarpus	0.29	0.68
Ficus	0.39	0.87
Pometia	0.63	2.48

Notes:
* : Family name.
** : Average value of the hardness in Air Dry Condition.

Table 5. Average Air-dried hardness of Three Different Surfaces (End, Tangential and Radial) of 19 Togian Wood Species and its Classification.

No.	Wood Species	SG	E	T (kg/mm²)	R	Class*
1.	*Koordersiodendron*	0.72	7.67	2.54	2.35	III
2.	*Canarium*	0.57	6.20	1.97	2.00	III
3.	*Lophopetalum*	0.47	5.61	1.73	1.22	III
4.	*Terminalia*	0.69	8.86	4.02	3.53	V
5.	*Octomeles*	0.38	3.31	1.04	0.76	II
6.	*Gonystylus*	0.58	7.09	2.22	1.76	III
7.	*Calophyllum*	0.51	5.89	1.92	1.20	III
8.	*Litsea*	0.45	4.81	1.61	1.30	III
9.	*Dysoxylum*	0.54	6.17	1.95	1.48	III
10.	*Artocarpus*	0.29	2.79	0.68	0.54	I
11.	*Ficus*	0.39	4.12	0.87	0.94	I
12.	*Myristicaceae***	0.49	4.22	1.68	1.00	III
13.	*Eugenia*	0.75	9.11	2.63	2.59	IV
14.	*Podocarpus*	0.51	5.99	2.31	1.46	III
15.	*Pometia*	0.63	8.18	2.48	2.31	III
16.	*Madhuca*	1.08	13.17	7.77	5.31	V
17.	*Palaquium*	0.60	6.70	2.33	1.70	III
18.	*Ailanthus*	0.46	4.99	1.59	0.99	II
19.	*Heritiera*	0.57	7.06	2.32	1.49	III

Notes:
* : Tangential surface hardness is classified based on the classification used in Japan Forest Experiment Station.
** : Family name.
E : Hardness of end surface.
T : Hardness of tangential surface.
R : Hardness of radial surface.
SG : Specific gravity.

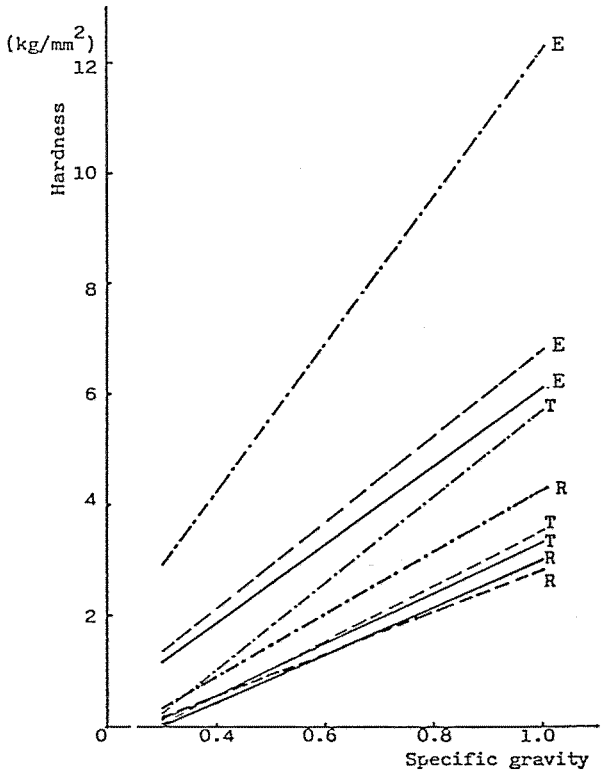

Fig. 3. Relationship between hardness and specific gravity of three different surfaces and three different conditions.

Notes:

– – – – : Green condition E: End surface
– – – – – : Air Dry condition T: Tangential surface
——— : Boiled condition R: Radial surface

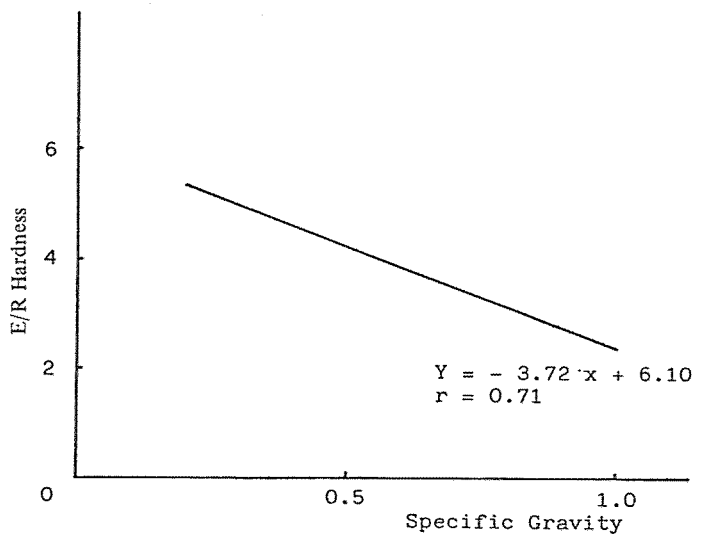

Fig. 4. Ratio of End to Radial Surface Hardness in Various Specific Gravity.

Notes:

E : End surface.
R : Radial surface.
r : Correlation coefficient.

group II.

Observation on the hardness calculations for specimens from group II also indicated that not all of the hardness of the observed species could be reduced by boiling treatment. A higher hardness value on tangential surface is found in eight species of group I and nine species of group II. Although hardness of those species increased after treated by boiling treatment, only some of them had the hardness value higher than 1 kg/mm^2, they were *Palaquium sp.* and *Heritiera sp.* from group I and *Koordersiodendron sp., Canarium sp., Dysoxylum sp.* and *Heritiera sp.* from group II.

The results of group II in Table 3 show that in general, air drying treatment could increase hardness of a green condition wood as much as 1.7 times, while a reduction of 5% might be expected by boiling a green condition wood in 100°C water for at least four hours. Table 3 also shows that the effect of boiling treatment on tangential surface of green wood is in the average of 5% reduction. Therefore for some species boiling is supposed to be the suitable treatment before they will be processed in a wood industry such as log peeling in plywood industry or any other processing in other industry in which a low hardness on tangential surface is desirable. For other uses, in which high hardness wood is an important factor then an air drying or boiling treatment for some species could be applied to increase their hardness.

(5) Hardness from Pith to Bark.

Each of the nineteen species came from group II was measured its hardness from pith to bark. Based on the data obtained in this measurement, then hardness distribution from pith to bark of those nineteen species could be classified into five general patterns of the hardness distribution. These five general patterns are shown in Fig. 5. In pattern one, high hardness value begins in the area near the pith and the value gradually decreases until it reaches a quite low position, then it gradually increases to a higher position than the initial value and finally down again to a value of approximately the same with the initial value. *Terminalia sp.* and *Octomeles sp.* belong to this pattern.

Hardness in pattern two and three show that in the area near the pith, the value is the lowest whereas in the area near the bark the value reaches its maximum point, in other word, the longer the distance of a given wood from its pith, the higher the value of the hardness. The difference between these two patterns is that the rate of increment in pattern two is higher than the rate in pattern three. Pattern two was found in *Koordersiodendron sp., Canarium sp.* and *Palaquium sp.* whereas *Litsea sp.*, Myristicaceae, *Eugenia sp., Madhuca sp.* and *Ailanthus sp.* belong to pattern three.

Pattern four, this pattern begins with an almost straight line from the area near the pith until an area of about half of its radius. The line is then up until a distance of about 0.7 of its radius, from this point the line is then down to a position of about the same with its initial position. *Gonystylus sp., Podocarpus sp.* and *Heritiera sp.* are represented by this pattern.

Pattern five, the graph in pattern five fluctuates in the same rate. Of the nineteen Togian wood species used in this study, six of them belong to this pattern. They are *Lophopetalum sp., Calophyllum sp., Dysoxylum sp., Artocarpus sp., Ficus sp.* and *Pometia sp.*

Classification of Nineteen Togian wood species based on the pattern of the hardness from pith to bark is presented with its specific gravity and average air-dried hardness value in Table 4.

(6) Hardness Classification.

Table 5 presents wood hardness of three different surfaces in air dry condition for nineteen species of group II. A classification which is based on a different criterion from the previous classification is also presented in Table 5. Air dried wood hardness on tangential surface of those nineteen species had been determined their classes here, in accordance with the classification used by Japan Forest Experiment Station. Air dried wood had been used in this classification simply because this condition is easy to be obtained. If we compare this classification with the previous classification, then it is clear that there is no relationship between those two classifications. *Terminalia sp.* and *Octomeles sp.*, for example, they belong to the same pattern, but they do not belong to the same class in Table 4. Classification in Table 5 also shows that most of the Togian wood species belong to Class III. Based on the fact that in general air dried and boiled wood have hardness 1.7 and 0.95 times as much as green wood respectively, then with some exception or in general those belong to Class III in Table 5 are considered to be easy to be peeled when they are in green or boiled wood conditions.

6.1.4 Conclusions

Hardness test is a simple and easy method as a preliminary test for determining the characteristics of a given wood, especially for wood which properties varied significantly. Hardness value can also be used for determining the use of a given wood. This is supported by the fact that there is a strong correlation between hardness and specific gravity. Other studies such as the

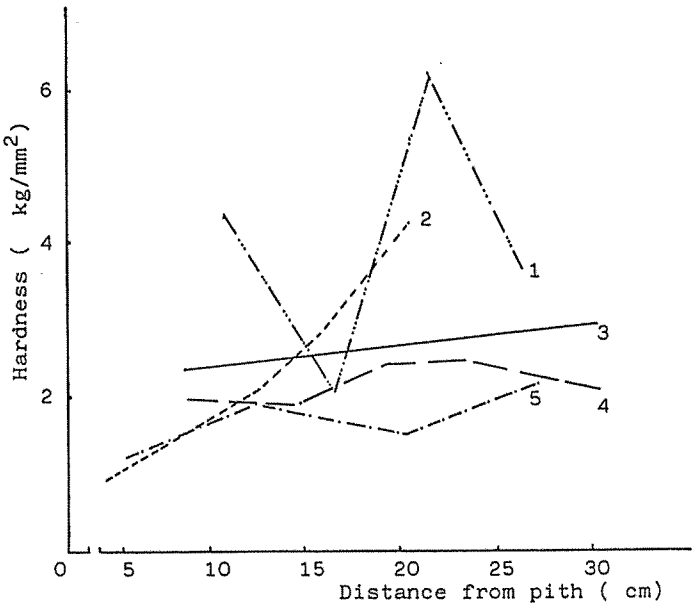

Fig. 5. General pattern of air dry hardness of tangential surface from pith to bark for nineteen Togian wood species.

Notes:

1. —·—·—·— : *Terminalia sp.*
2. ---------- : *Koordersiodendron sp.*
3. ———— : *Eugenia sp.*
4. — — — — : *Gonystylus sp.*
5. — — — — : *Lophopetalum sp.*

relationships between hardness of woods used in this study and its modulus of elasticity or any other mechanical properties as well as physical properties are considered necessary to do.

Based on the results obtained in this study then the following conclusions are drawn:

1. Average specific gravity for those nineteen species belong to group II were in the range of 0.29 to 1.08.
2. Of the nineteen species used in group II, *Artocarpus sp.* had the lowest hardness value and *Madhuca sp.* had the highest hardness value.
3. Hardness of end, tangential and radial surface increased with increasing specific gravity. The relationships between specific gravity and hardness, could be reasonably described by linear regression equations.
4. Among three different surfaces, the highest hardness was on end surface while the lowest was on the radial surface.
5. Air dried wood had higher hardness value than two other specimen conditions.
6. The higher the specific gravity of a given wood the lower the ratio of end to radial surface hardness.
7. For some species, boiling is supposed to be a suitable treatment for reducing their hardness.
8. There are five general pattern of the distribution of tangential surface hardness from pith to bark.
9. Classification based on the distribution of the hardness from pith to bark gives a different result from that of the classification based on the hardness on tangential surface of the same specimen condition.
10. Most of the Togian woods belong to Class III of the classification used by Japan Forest Experiment Station.

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6・1・5 概　　要

6・1・5・1 はじめに

ＪＩＳＺ2117：木材のかたさ試験に準じたブリネルかたさ試験を行った。かたさは強さと並んで加工適性につながる材質評価の指標となりうる重要なものである。また現場における適用も可能な簡易な試験であり今後のデーターの集積が望まれるものである。

6・1・5・2 測定方法

試験は生材，気乾材および生材を煮沸処理した煮沸材で行った。煮沸処理は試験片にしてから4時間行い，その後水中で冷却後湿潤状態で試験を行った。

使用した樹種は7船を中心としたものである。まず樹心部および樹皮部になるべく近い部分をとり，その間を4～5分して，4～5ケの試験片をとり，樹幹内におけるかたさ分布を求められるようにした。

用いた試験機は前川製作所製のブリネル硬度計で直径10㎜の鋼球のめりこみ深さ$1/\pi$㎜となる時の荷重Ｐを求め，次式によりブリネルかたさとする。

$$\text{かたさ} = P/10 \quad \text{kg/mm}^2$$

6・1・5・3　結果の検討

(1)　比重とかたさ

試験終了後の全試験片より気乾比重（X）を求め，気乾比重と生材，気乾材，煮沸材のかたさ（Y）との間の相関を求めた。rは相関係数を示す。

木口面かたさ

生　材	Y = 7.81 X − 0.98	r = 0.92
気乾材	Y = 13.37 X − 1.13	r = 0.96
煮沸材	Y = 7.12 X − 0.99	r = 0.93

板目面かたさ

生　材	Y = 5.06 X − 1.48	r = 0.88
気乾材	Y = 7.85 X − 2.13	r = 0.92
煮沸材	Y = 4.65 X − 1.31	r = 0.89

柾目面かたさ

生　材	Y = 3.84 X − 1.01	r = 0.87
気乾材	Y = 5.63 X − 1.36	r = 0.93
煮沸材	Y = 4.32 X − 1.31	r = 0.91

かたさと比重との間には良い相関関係がみられ特に気乾材かたさや，木口面かたさの相関係数は0.9以上を示す。

(2)　かたさの異方性，異方度と比重

次にかたさの異方性を求めるため各試験片における柾目面，板目面，木口面かたさの比を求めた結果を表2に示す。総平均におけるかたさの異方性は柾目面かたさを1.00とした場合，板目面かたさ1.24，木口面かたさ3.54である。かたさは柾目面，板目面，木口面の順に大となる。

またかたさの最も小さい柾目面かたさと最も大きい木口面かたさの比をかたさ異方度とし，全試験片について気乾比重（X）と異方度（Y）との間の相関を求めた。rは相関係数を示す。

$$Y = -3.72\,X + 6.10 \qquad r = 0.71$$

この結果は重い材ほど異方度が小さいことを示している。

(3)　かたさの樹幹内分布，かたさ変動比

樹幹内における半径方向のかたさ分布を表示するために樹幹の最も樹心に近い位置よりとった試片（半径の約⅙位置）のかたさと最も外側の樹皮に近い位置よりとった試片（樹皮直近）のかたさの比を求めかたさ変動比としてAppendix 6に示した。生材，気乾材，煮沸材における木口，板目，柾目面かたさすべての平均値である。

脆心材と思われる極端に比重の低い材が最も内側試験片をなす樹種ではかたさ変動比は大きくなる。また針葉樹材であるPodocarpus，および極めて比重が高く平均気乾比重で1.08を示したMadhuca材ではかたさ変動比が1.00以下となったが，その他の材での変動比は1.2～1.7の間の値を示し，外側ほどかたさは大となる。

(4) 生材，気乾材，煮沸材かたさ

一般にかたさは乾燥することにより増大し，煮沸することにより低下する。生材，気乾材，煮沸材のかたさの対比結果を表3に示す。また各樹種での生材，気乾材，煮沸材のかたさの比を各材面別に平均したものを表3の最下欄に示した。

最終的にそれらをまとめて総平均した結果は次のようであった。

気乾材かたさ／生材かたさ ＝ 1.70
煮沸材かたさ／生材かたさ ＝ 0.95

煮沸によるかたさの減少はかたさの大きい木口面かたさで顕著で1 ： 0.89を示したが，かたさの小さい柾目面かたさでは1 ： 1.01となりほとんど変化がない。

江草氏により板目面かたさが1.00以下の材では裏われ率の少ないロータリー切削が可能であり，煮沸により板目面かたさが1.00になればこの材は煮沸後ロータリー切削可能であるとの判断がなされている。

当初この観点に立って5，6船の材について板目面かたさのみの試験が行われた。この試験では樹幹内の分布や木口面，柾目面のかたさは求めていない。

5，6，7船を通じて板目面かたさにつき煮沸の効果を求めた結果，煮沸材のかたさの生材かたさに対する比の平均は0.95を示した。

しかし煮沸によりかたさの増大する樹種の存在することも知られている。今回の試験樹種のうちでもCanarium，Ficus，Ailanthus，Heritieraではかたさは煮沸により増大ないしは不変化であった。その他Lophopetalum，Calophyllum，Dysoxylum，Sandricum，Myristicaceaeの材ではかたさの増大がみられ，またPalaquiumではかたさの増大する個体と減少するものとがみられた。

今回の煮沸処理時間は100℃，4時間と短くとったが，江草氏のデーターによると24～144時間の煮沸処理により南洋材では大略60℃で80％，80℃で65％，90℃で55％にかたさは減少するとされる。南洋材は内地材に比し10％ほど低下率は悪く，この範囲では煮沸時間の影響はあまりみられない。

引　用　文　献

江草義正；南洋材の性質と加工，木材加工講座テキスト，日本木材加工技協，昭和43年

Appendix 1. List of Twenty-two Wood Species Used for Hardness Test. Group I.

No.	Family	Botanical Name	No. of tested* timber
1.	Anacardiaceae	*Dracontomelon sp.*	1
2.	Anacardiaceae	*Spondias sp.*	4
3.	Burseraceae	*Canarium sp.-1***	6
4.	Burseraceae	*Santiria sp.-1*	11
5.	Burseraceae	*Santiria sp.-2*	12
6.	Combretaceae	*Terminalia sp.-1*	15
7.	Combretaceae	*Terminalia sp.-2*	16
8.	Combretaceae	*Terminalia sp.-3*	17
9.	Euphorbiaceae	*Sapium sp.-1*	26
10.	Lauraceae	*Litsea sp.-1*	31
11.	Lauraceae	*Litsea sp.-2*	32
12.	Meliaceae	*Aglaia sp.-1*	35
13.	Meliaceae	*Sandoricum sp.-1*	40
14.	Moraceae	*Ficus sp.-1*	43
15.	Sapotaceae	*Palaquium sp.-1*	56
16.	Simarubaceae	*Ailanthus sp.*	61
17.	Sonneratiaceae	*Duabanga sp.-1*	63
18.	Sonneratiaceae	*Duabanga sp.-2*	64
19.	Sonneratiaceae	*Duabanga sp.-3*	65
20.	Sterculiaceae	*Heritiera sp.-1*	67
21.	Sterculiaceae	*Sterculia sp.-1*	72
22.	Sterculiaceae	*Sterculia sp.-2*	73

Notes:

* : See 1.1 Wood Identification Table 1.

**: More than one species of this group used for this test.

Appendix 2. List of Nineteen Wood Species Used for Hardness Test. Group II.

No.	Family	Botanical Name	No. of tested* timber
1.	Anacardiaceae	*Koordersiodendron sp.*	2
2.	Burseraceae	*Canarium sp.*	7
3.	Celastraceae	*Lophopetalum sp.*	14
4.	Combretaceae	*Terminalia sp.*	18
5.	Datiscaceae	*Octomeles sp.*	23
6.	Gonystylaceae	*Gonystylus sp.*	28
7.	Guttiferae	*Calophyllum sp.*	29
8.	Lauraceae	*Litsea sp.*	33
9.	Meliaceae	*Dysoxylum sp.*	39
10.	Moraceae	*Artocarpus sp.*	42
11.	Moraceae	*Ficus sp.*	44
12.	Myristicaceae	–	45
13.	Myrtaceae	*Eugenia sp.*	47
14.	Podocarpaceae	*Podocarpus sp.*	49
15.	Sapindaceae	*Pometia sp.*	53
16.	Sapotaceae	*Madhuca sp.*	55
17.	Sapotaceae	*Palaquium sp.*	57
18.	Simarubaceae	*Ailanthus sp.*	62
19.	Sterculiaceae	*Heritiera sp.*	68

*: See 1.1 Wood Identification Table 1.

Appendix 3. Hardness of Each Specimen for 22 Species. Group I.

Wood Species	No.	E		T		R	
		G	B	G	B	G	B
1. *Dracontomelon*	1	2.43	2.54	0.82	0.95	0.79	0.90
	2	3.03	3.33	0.53	0.93	0.56	1.06
	3	1.90	2.47	0.51	1.15	0.50	1.20
	4	2.14	3.95	0.66	0.96	0.88	1.00
	5	2.16	3.75	0.50	1.26	0.79	0.88
2. *Spondias*	1	2.62	1.98	0.71	0.85	0.81	0.76
	2	3.03	2.28	0.94	0.80	0.77	0.82
	3	3.10	2.00	0.66	0.73	0.88	0.71
	4	2.20	2.88	0.82	0.72	0.83	0.76
	5	2.56	2.54	0.61	0.73	0.72	0.88
3. *Canarium*	1	2.78	2.10	0.80	0.91	1.38	0.91
	2	2.89	2.76	1.01	0.80	1.30	0.96
	3	3.15	2.97	1.10	0.87	1.19	0.86
	4	2.28	2.77	0.88	1.20	1.44	0.95
	5	3.78	2.47	1.15	1.30	1.20	0.95
4. *Santiria-1*	1	3.10	2.86	1.25	0.63	1.09	0.63
	2	2.85	2.67	0.94	0.98	1.40	0.63
	3	3.83	2.70	1.24	1.03	1.14	0.52
	4	3.42	2.80	1.35	1.07	0.64	0.70
	5	3.27	2.93	1.19	1.15	1.17	0.68
5. *Santiria-2*	1	3.48	2.89	1.29	1.15	0.96	0.93
	2	3.88	2.55	1.33	1.26	0.97	1.10
	3	3.89	2.64	1.20	1.24	1.09	1.03
	4	3.43	3.04	1.28	1.31	1.10	1.00
	5	3.38	3.10	1.32	1.22	1.06	0.96
6. *Terminalia-1*	1	3.55	3.42	0.94	1.08	0.79	0.93
	2	4.02	3.29	0.94	1.20	0.72	1.18
	3	2.71	4.00	1.24	1.03	0.60	1.21
	4	3.34	4.02	1.32	0.94	0.88	1.06
	5	3.61	3.27	0.86	0.92	0.72	1.42
7. *Terminalia-2*	1	2.70	3.04	0.89	0.61	0.64	0.51
	2	3.23	1.88	1.00	0.69	0.82	0.55
	3	3.09	2.63	1.14	0.61	0.62	0.50
	4	3.36	2.39	0.71	0.65	0.71	0.43
	5	3.16	2.53	0.86	0.62	0.68	0.39
8. *Terminalia-3*	1	4.22	4.32	1.72	1.68	1.44	1.29
	2	4.22	3.45	1.66	1.60	1.44	1.48
	3	4.43	3.72	1.74	1.68	1.40	1.28
	4	4.27	3.60	1.66	1.55	1.40	1.03
	5	4.28	3.76	1.78	1.67	1.46	1.22
9. *Sapium-1*	1	2.20	1.07	0.70	0.53	0.48	0.32
	2	1.78	1.09	0.64	0.55	0.43	0.35
	3	2.01	1.10	0.59	0.52	0.50	0.31
	4	2.25	1.13	0.70	0.54	0.43	0.27
	5	1.85	1.81	0.55	0.52	0.52	0.46

(Continued)

Wood Species	No.	E		T		R	
		G	B	G	B	G	B
10. *Litsea-1*	1	1.94	2.25	0.85	0.60	0.64	0.72
	2	2.56	1.97	0.53	0.69	0.78	0.58
	3	1.84	1.60	0.88	0.52	0.76	0.80
	4	2.43	2.09	0.76	0.92	0.70	0.67
	5	1.95	1.98	0.75	0.71	0.66	0.63
11. *Litsea-2*	1	2.77	2.03	0.70	0.68	0.61	0.70
	2	2.64	1.91	0.89	0.66	0.78	0.62
	3	2.83	1.83	0.95	0.64	0.70	0.65
	4	2.60	2.31	0.97	0.59	0.64	0.63
	5	2.60	1.91	0.75	0.66	0.68	0.62
12. *Aglaia-1*	1	3.70	2.79	1.57	1.03	1.56	0.72
	2	3.64	3.06	1.39	1.02	1.49	0.60
	3	3.52	2.43	1.59	1.12	0.88	0.50
	4	3.51	2.44	1.28	1.15	1.52	0.80
	5	4.12	2.73	1.53	1.03	1.01	0.58
13. *Sandoricum-1*	1	2.00	1.86	0.75	0.74	0.57	0.62
	2	2.33	1.72	0.82	0.96	0.73	0.78
	3	2.04	1.97	0.76	0.96	0.55	0.63
	4	2.31	1.88	0.76	0.88	0.60	0.76
	5	2.28	2.00	0.76	0.82	0.58	0.57
14. *Ficus-1*	1	2.69	2.66	0.77	0.72	0.54	0.77
	2	2.87	2.72	0.80	0.63	0.86	0.67
	3	3.11	3.06	0.72	0.83	0.72	0.73
	4	2.29	2.35	0.70	0.99	0.69	0.80
	5	2.78	2.41	0.78	0.88	0.71	0.68
15. *Palaquium-1*	1	2.89	2.76	0.96	1.21	0.61	0.74
	2	2.75	2.61	0.77	1.15	0.53	0.99
	3	2.47	2.81	0.80	1.19	0.60	0.92
	4	2.92	3.22	0.89	1.24	0.58	0.92
	5	2.91	2.92	0.79	1.17	0.66	0.99
16. *Ailanthus-1*	1	2.07	1.98	0.63	0.64	0.50	0.47
	2	2.18	1.98	0.65	0.52	0.49	0.45
	3	2.11	2.00	0.52	0.57	0.49	0.52
	4	2.04	2.01	0.61	0.62	0.45	0.40
	5	2.17	2.20	0.64	0.63	0.51	0.41
17. *Duabanga-1*	1	1.71	1.20	0.59	0.30	0.61	0.50
	2	2.18	1.17	0.58	0.34	0.52	0.44
	3	2.06	1.00	0.67	0.39	0.54	0.43
	4	1.79	1.53	0.68	0.39	0.60	0.42
	5	2.10	1.75	0.72	0.28	0.57	0.53
18. *Duabanga-2*	1	1.15	0.79	–	0.43	0.54	0.54
	2	1.93	0.67	0.53	0.45	0.42	0.53
	3	1.05	1.04	0.72	0.61	0.49	0.52
	4	0.93	0.77	0.73	0.57	0.57	0.74
	5	1.30	1.03	0.73	0.48	0.48	0.57

(Continued)

Wood Species		No.	E		T		R	
			G	B	G	B	G	B
19.	*Duabanga-3*	1	1.38	2.21	0.61	0.29	0.52	0.56
		2	1.92	1.57	0.68	0.40	0.51	0.57
		3	1.28	1.82	0.63	0.54	0.62	0.64
		4	1.89	1.47	0.54	0.58	0.54	0.50
		5	2.14	1.61	0.43	0.48	0.50	0.60
20.	*Heritiera-1*	1	3.15	3.66	1.18	1.11	0.97	1.47
		2	3.19	3.70	1.19	1.33	1.00	1.30
		3	4.39	4.56	1.16	1.07	0.94	1.16
		4	3.49	4.39	1.14	1.37	1.08	1.53
		5	3.69	4.08	1.14	1.36	1.19	1.31
21.	*Sterculia-1*	1	1.62	1.57	0.48	0.42	0.29	0.28
		2	1.62	1.55	0.44	0.39	0.32	0.31
		3	1.83	1.83	0.45	0.45	0.34	0.27
		4	1.81	1.70	0.50	0.38	0.40	0.36
		5	2.26	1.47	0.42	0.40	0.33	0.31
22.	*Sterculia-2*	1	1.43	1.47	0.42	0.41	0.33	0.27
		2	2.22	1.85	0.33	0.42	0.32	0.38
		3	2.18	1.99	0.42	0.44	0.49	0.37
		4	1.50	1.96	0.39	0.31	0.36	0.35
		5	2.17	1.86	0.37	0.47	0.40	0.30

Notes:
E : End surface.
T : Tangential surface.
R : Radial surface.
No. : Specimen's number.
G : Green wood.
B : Boiled wood.
All of the hardness values are in kg/mm^2.

Appendix 4. Hardness from Pith to Bark for 19 Species. Group II.

Wood Species	DP	SG	End			Tangential			Radial		
			G	AD	B	G	AD	B	G	AD	B
1. *Koordersiodendron*	20	0.79	4.96	9.28	4.53	2.26	4.21	1.82	1.78	2.78	1.97
	16	0.82	4.30	9.42	3.98	2.37	2.96	2.51	2.45	2.94	2.21
	12	0.73	3.19	7.63	3.61	1.20	2.07	2.55	1.14	2.61	1.34
	4	0.53	1.86	4.33	1.98	0.88	0.90	0.56	0.64	1.06	0.45
2. *Canarium*	24	0.64	3.48	6.80	3.16	1.12	2.63	1.23	1.09	1.97	1.27
	16	0.65	3.27	7.15	3.08	1.91	2.21	2.07	1.07	2.87	1.22
	11	0.55	2.40	6.25	2.40	0.62	2.00	1.28	0.87	1.94	1.07
	5	0.44	2.15	4.61	2.08	0.63	1.03	0.63	0.61	1.23	0.69
3. *Lophopetalum*	27	0.54	3.35	5.82	3.12	1.04	2.22	1.16	0.81	1.41	0.80
	20	0.50	3.19	6.62	2.84	0.95	1.56	0.84	0.75	1.36	0.74
	12	0.45	2.68	5.88	2.57	0.84	1.92	0.98	0.65	1.19	0.71
	5	0.39	2.17	4.11	2.11	0.57	1.22	0.69	0.49	0.93	0.48
4. *Terminalia*	26	0.79	5.06	9.37	5.44	2.96	3.69	2.16	1.54	3.05	1.90
	21	–	7.10	11.17	6.63	4.75	6.22	3.56	2.94	5.22	3.52
	16	0.59	3.16	6.81	2.85	1.36	2.12	1.34	0.84	2.58	1.03
	11	–	3.73	8.08	3.13	1.78	4.06	1.46	1.79	3.25	1.64
5. *Octomeles*	29	0.38	1.94	3.35	1.72	0.64	0.93	0.56	0.56	0.83	0.45
	23	0.54	2.42	4.04	2.40	1.14	1.76	1.10	1.41	1.10	0.89
	15	0.36	2.09	3.49	1.81	0.55	0.84	0.60	0.49	0.73	0.59
	10	0.33	1.52	3.05	1.49	0.53	0.69	0.49	0.45	0.57	0.47
	6	0.28	1.36	2.60	1.29	0.40	0.98	0.38	0.29	0.58	0.39
6. *Gonystylus*	30	0.57	4.04	7.32	3.64	1.40	2.17	1.27	1.18	1.61	0.91
	23	0.58	3.81	7.14	3.30	1.30	2.52	1.16	0.98	1.78	0.88
	19	0.60	4.23	7.30	3.48	1.30	2.46	1.20	0.95	1.76	0.89
	14	0.58	3.69	7.27	3.54	1.25	1.96	0.98	0.95	1.86	0.87
	8	0.55	3.04	6.43	2.48	0.99	1.99	0.92	0.80	1.79	1.05
7. *Calophyllum*	25	0.66	4.14	7.24	3.35	1.18	2.36	1.40	1.04	1.52	0.94
	20	0.51	3.92	6.64	3.17	1.19	2.56	1.05	0.87	1.47	0.90
	14	0.57	2.95	5.60	2.89	0.81	1.95	0.81	0.73	1.14	0.82
	7	0.31	2.19	4.07	1.81	0.52	0.80	0.73	0.54	0.68	0.44

(Continued)

Wood Species	DP	SG	End			Tangential			Radial		
			G	AD	B	G	AD	B	G	AD	B
8. *Litsea*	34	0.50	3.00	5.27	2.68	1.29	2.20	0.97	1.19	1.49	0.80
	28	0.51	2.94	5.41	2.27	1.42	2.25	1.30	1.09	1.54	0.82
	21	0.49	3.09	5.06	2.72	1.24	1.53	1.10	0.92	1.47	0.86
	16	0.42	2.91	5.24	2.18	1.37	1.36	0.91	0.83	1.25	0.58
	9	0.31	2.27	3.09	1.66	1.00	0.71	0.86	0.78	0.75	0.66
9. *Dysoxylum*	33	0.61	3.85	6.72	3.23	1.40	2.68	1.41	1.13	1.76	1.00
	23	0.57	4.01	7.08	3.34	1.51	2.16	1.73	1.15	1.59	1.24
	19	0.56	3.70	6.59	3.40	1.64	2.36	1.75	1.41	1.65	1.37
	13	0.50	3.36	5.53	2.62	1.12	1.56	1.35	0.96	1.31	0.80
	6	0.45	3.18	4.95	2.33	0.96	0.99	0.84	1.17	1.07	0.87
10. *Artocarpus*	27	0.34	1.75	2.85	1.45	0.46	0.78	0.46	0.42	0.78	0.41
	20	0.28	1.36	2.68	1.35	0.50	0.69	0.45	0.33	0.55	0.32
	13	0.32	1.68	3.57	1.44	0.45	0.80	0.45	0.69	0.55	0.45
	5	0.21	0.73	2.07	0.83	0.60	0.43	0.29	0.28	0.29	0.37
11. *Ficus*	28	0.51	2.86	5.71	2.54	0.51	1.39	0.52	0.81	1.53	0.83
	23	0.43	2.36	4.68	2.11	0.63	0.79	0.65	0.52	1.11	0.62
	16	0.40	2.31	4.32	2.13	0.50	1.11	0.59	0.48	0.88	0.58
	10	0.37	1.85	3.87	1.72	0.35	0.70	0.39	0.40	0.74	0.44
	5	0.26	0.93	2.00	0.86	0.36	0.34	0.33	0.22	0.46	0.23
12. *Myristicaceae**	28	0.53	2.48	4.04	1.98	1.06	1.92	1.02	0.68	1.14	0.66
	21	0.50	2.20	4.39	1.96	1.03	2.00	1.06	0.67	1.06	0.64
	16	0.50	2.36	4.87	2.06	0.76	1.72	0.82	0.68	0.98	0.71
	9	0.43	1.42	3.56	1.50	0.65	1.09	0.67	0.40	0.80	0.57
13. *Eugenia*	30	0.71	5.08	8.98	4.77	1.92	2.97	2.00	1.95	3.07	1.91
	23	0.76	5.08	–	4.53	1.92	–	1.75	1.41	–	1.86
	15	0.77	4.49	8.64	3.84	1.95	2.56	1.55	1.49	2.30	1.44
	8	0.77	3.82	9.72	3.73	1.41	2.37	1.41	1.61	2.40	1.49
14. *Podocarpus*	24	0.51	3.63	5.99	2.63	0.83	1.81	0.59	1.14	1.43	0.68
	20	0.51	3.70	5.91	2.55	1.13	2.35	0.61	0.98	1.43	0.68
	12	0.52	3.66	5.73	2.55	1.03	2.73	0.67	1.06	1.46	0.73
	7	0.51	3.96	6.32	2.75	1.09	2.34	0.67	1.13	1.50	0.74

(Continued)

Wood Species	DP	SG	End			Tangential			Radial		
			G	AD	B	G	AD	B	G	AD	B
15. *Pometia*	25	0.69	4.50	8.83	3.94	1.75	2.53	1.44	1.43	2.75	1.64
	18	0.70	4.12	9.02	3.66	1.23	2.53	1.27	1.24	2.96	1.11
	12	0.58	3.03	7.11	2.90	0.94	2.78	0.92	0.82	1.92	0.84
	6	0.55	3.11	7.76	2.82	0.78	2.06	0.72	0.83	1.62	0.72
16. *Madhuca*	40	1.05	7.39	13.86	6.65	3.61	8.56	3.69	3.00	5.20	3.26
	34	1.10	8.67	13.79	7.67	5.34	7.59	5.17	4.64	5.54	4.75
	27	1.11	9.41	12.77	8.02	6.00	7.48	4.97	5.37	5.27	4.40
	18	1.04	7.92	12.25	6.74	4.78	7.46	4.84	3.44	5.21	4.32
17. *Palaquium*	32	0.64	4.19	7.02	3.25	1.72	2.78	1.74	1.33	1.95	1.44
	24	0.63	3.74	7.38	3.30	1.73	2.61	1.55	1.69	1.77	1.20
	18	0.64	3.62	7.23	3.10	2.06	2.58	1.44	1.68	2.01	1.32
	11	0.50	3.02	5.17	2.68	1.21	1.35	0.89	1.03	1.06	0.65
18. *Ailanthus*	24	0.49	2.48	5.10	2.37	0.76	1.68	0.81	0.50	1.14	0.56
	16	0.43	2.08	4.88	1.85	0.38	1.49	0.60	0.43	0.84	0.40
19. *Heritiera*	24	0.64	4.71	8.41	4.15	1.42	2.39	1.46	1.22	1.83	1.61
	17	0.56	3.93	6.56	3.76	1.39	2.29	1.47	1.07	1.44	1.48
	12	0.55	3.46	6.27	3.29	1.42	2.55	1.72	1.13	1.38	1.26
	5	0.54	4.25	6.98	3.63	1.17	2.04	1.48	1.10	1.30	1.06

Notes:
DP : Distance from pith (cm).
SG : Air-dry specific gravity.
G : Green wood.
AD : Air-dried wood.
B : Boiled wood.
End : End surface.
Tangential : Tangential surface.
Radial : Radial surface.
* : Family name.
All of the hardness values are in kg/mm^2.

Appendix 5. Ratio of The Tangential and End Surface to Radial Surface Hardness in Three Different Testing Conditions for 19 Species. Group II.

	Wood Species		Green			Air-dried			Boiled	
		SG	R	T	E	R	T	E	R	T	E
1.	*Koordersiodendron*	0.72	1	1.17	2.57	1	1.04	3.39	1	1.53	2.80
2.	*Canarium*	0.57	1	1.14	3.13	1	1.00	3.25	1	1.20	2.57
3.	*Lophopetalum*	0.47	1	1.25	4.24	1	1.41	4.59	1	1.35	3.94
4.	*Terminalia*	0.80	1	1.56	2.90	1	1.12	2.59	1	1.09	2.38
5.	*Octomeles*	0.38	1	1.13	3.50	1	1.35	4.46	1	1.14	3.21
6.	*Gonystylus*	0.58	1	1.29	3.89	1	1.27	4.04	1	1.22	3.60
7.	*Calophyllum*	0.49	1	1.14	4.15	1	1.68	5.05	1	1.33	3.68
8.	*Litsea*	0.45	1	1.33	3.00	1	1.20	3.76	1	1.36	3.11
9.	*Dysoxylum*	0.54	1	1.08	3.15	1	1.29	4.22	1	1.35	2.87
10.	*Artocarpus*	0.29	1	1.35	3.33	1	1.30	5.54	1	1.08	3.30
11.	*Ficus*	0.39	1	1.08	4.35	1	0.91	4.49	1	1.00	3.56
12.	*Myristicaceae**	0.49	1	1.46	3.49	1	1.67	4.28	1	1.39	2.60
13.	*Eugenia*	0.75	1	1.13	2.90	1	1.02	3.58	1	1.00	2.53
14.	*Podocarpus*	0.51	1	0.95	3.48	1	1.59	4.14	1	0.90	3.71
15.	*Pometia*	0.63	1	1.08	3.48	1	1.12	3.69	1	1.03	3.30
16.	*Madhuca*	1.08	1	1.22	2.07	1	1.47	2.48	1	1.12	1.77
17.	*Palaquium*	0.60	1	1.18	2.63	1	1.36	3.11	1	1.24	2.87
18.	*Ailanthus*	0.46	1	1.20	4.90	1	1.62	5.14	1	1.48	4.43
19.	*Heritiera*	0.57	1	1.20	3.61	1	1.58	4.77	1	1.17	2.90
	Average		1	1.20	3.41	1	1.32	4.03	1	1.21	3.13

Notes:
* : Family name.
SG : Specific gravity.
R : Radial surface.
T : Tangential surface.
E : End surface.

Appendix 6. Ratio of The Outermost To The Innermost Hardness For 19 Species. Group II.

	Wood Species	Share	Ratio
1.	*Koordersiodendron*	0.20	3.04
2.	*Canarium*	0.23	1.78
3.	*Lophopetalum*	0.19	1.61
4.	*Terminalia*	0.39	1.25
5.	*Octomeles*	0.19	1.40
6.	*Gonystylus*	0.27	1.23
7.	*Calophyllum*	0.28	2.11
8.	*Litsea*	0.27	1.48
9.	*Dysoxylum*	0.18	1.51
10.	*Artocarpus*	0.17	1.67
11.	*Ficus*	0.18	2.96
12.	*Myristicaceae**	0.30	1.49
13.	*Eugenia*	0.28	1.26
14.	*Podocarpus*	0.26	0.90
15.	*Pometia*	0.24	1.65
16.	*Madhuca*	0.41	0.93
17.	*Palaquium*	0.33	1.64
18.	*Ailanthus*	0.65	1.32
19.	*Heritiera*	0.21	1.21

Notes:
Share : Share of the innermost specimen on the radius of the log.
Ratio : Ratio of the outermost to the innermost hardness of the same radius of log.
* : Family name.

Appendix 7. Ratio of Boiled to Green Wood Hardness on Three Different Surfaces for 22 Species. Group I.

	Wood Species	E		T		R	
		G	B	G	B	G	B
1.	*Dracontomelon*	1	1.38	1	1.75	1	1.44
2.	*Spondias*	1	0.87	1	1.03	1	0.98
3.	*Canarium-1*	1	0.88	1	1.03	1	0.72
4.	*Santiria-1*	1	0.84	1	0.81	1	0.58
5.	*Santiria-2*	1	0.79	1	0.97	1	0.96
6.	*Terminalia-1*	1	1.04	1	0.97	1	1.57
7.	*Terminalia-2*	1	0.80	1	0.70	1	0.70
8.	*Terminalia-3*	1	0.88	1	0.96	1	0.88
9.	*Sapium-1*	1	0.61	1	0.83	1	0.72
10.	*Litsea-1*	1	0.93	1	0.92	1	0.94
11.	*Litsea-2*	1	0.97	1	0.76	1	0.94
12.	*Aglaia-1*	1	0.73	1	0.73	1	0.50
13.	*Sandoricum-1*	1	0.86	1	1.13	1	1.10
14.	*Ficus-1*	1	0.96	1	1.08	1	1.04
15.	*Palaquium-1*	1	1.03	1	1.42	1	1.52
16.	*Ailanthus*	1	0.96	1	0.98	1	0.92
17.	*Duabanga-1*	1	0.68	1	0.52	1	0.81
18.	*Duabanga-2*	1	0.68	1	0.75	1	1.16
19.	*Duabanga-3*	1	1.01	1	0.79	1	1.08
20.	*Heritiera-1*	1	1.14	1	1.08	1	1.30
21.	*Sterculia-1*	1	0.89	1	0.89	1	0.91
22.	*Sterculia-2*	1	0.96	1	1.05	1	0.87

Notes:

E : End surface.
T : Tangential surface.
R : Radial surface.
G : Green wood.
B : Boiled wood.

Appendix 8. Ratio of Air-Dried and Boiled Wood to Green Wood Hardness on Three Different Surfaces for 19 Species. Group II.

Wood Species	End			Tangential			Radial		
	G	AD	B	G	AD	B	G	AD	B
1. *Koordersiodendron*	1	2.03	0.92	1	1.56	0.94	1	1.38	1.01
2. *Canarium*	1	2.07	0.93	1	1.76	1.09	1	2.25	1.16
3. *Lophopetalum*	1	2.00	0.93	1	1.68	1.06	1	1.79	1.02
4. *Terminalia*	1	1.71	1.01	1	1.28	0.74	1	1.88	1.22
5. *Octomeles*	1	1.77	0.93	1	1.46	0.96	1	1.24	0.92
6. *Gonystylus*	1	1.85	0.89	1	1.74	0.88	1	1.45	0.88
7. *Calophyllum*	1	1.72	0.81	1	2.08	1.04	1	1.58	0.97
8. *Litsea*	1	1.76	0.82	1	1.38	0.81	1	1.44	0.76
9. *Dysoxylum*	1	1.77	0.86	1	1.59	1.08	1	1.37	0.98
10. *Artocarpus*	1	1.23	0.91	1	1.54	0.95	1	1.71	0.98
11. *Ficus*	1	1.99	0.91	1	2.05	1.09	1	1.93	1.13
12. *Myristicaceae**	1	1.90	0.85	1	1.88	1.00	1	1.57	0.99
13. *Eugenia*	1	1.85	0.90	1	1.43	0.91	1	1.56	1.09
14. *Podocarpus*	1	1.61	0.71	1	2.27	0.63	1	1.36	0.66
15. *Pometia*	1	2.08	0.89	1	1.76	0.93	1	1.11	1.03
16. *Madhuca*	1	1.61	0.88	1	1.68	0.94	1	1.30	0.98
17. *Palaquium*	1	1.88	0.84	1	1.46	0.87	1	1.24	0.86
18. *Ailanthus*	1	2.06	0.96	1	2.21	1.67	1	2.28	1.12
19. *Heritiera*	1	1.76	0.96	1	1.67	1.05	1	1.43	1.35
Average	1	1.82	0.89	1	1.71	0.95	1	1.57	1.01

Notes:
* : Family name.
G : Green wood.
AD: Air-dried wood.
B : Boiled wood.