Impact Factor:

ISRA (India)	= **6.317**	**SIS** (USA)	= **0.912**	**ICV** (Poland)	= **6.630**
ISI (Dubai, UAE)	= **1.582**	**РИНЦ** (Russia)	= **3.939**	**PIF** (India)	= **1.940**
GIF (Australia)	= **0.564**	**ESJI** (KZ)	= **8.771**	**IBI** (India)	= **4.260**
JIF	= **1.500**	**SJIF** (Morocco)	= **7.184**	**OAJI** (USA)	= **0.350**

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RESEARCH ON THE STRUCTURE AND PROPERTIES OF PTERYGOTA INDICA WOOD AS A RAW MATERIAL FOR PULP AND PAPER

***Abstract**: This research was conducted with the hope of supporting the development of Industrial Plantation Forests, because this wood is likely to be recommended as raw material for pulp and paper. The purpose of this study was to obtain a description of the structure and properties of Pterygota indica wood, as well as measurements of fiber dimensions from the base to the tip of the tree. The other objective is to determine the physical properties of wood, namely specific gravity, wood chemistry which is located at the base to the tip of the tree, the wood at the base to the tip of the deciduous tree, as well as Pterygota indica wood, which has different structures and wood properties. If we obtain data on some of the structures and properties of Pterygota indica wood, it is hoped that we can determine its suitability as a raw material for the pulp industry. Implementation this study used the ASTM D 1103–60 method/guideline (Anon, 2019). The results of this study indicate that Pterygota indica wood can be used as a raw material for the pulp and paper industry, and can also be used as carpentry wood or plywood, because this wood has a level/class of durable wood III.*

***Key words**: wood structure, wood properties, Pterygota indica.*

***Language**: English*

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Introduction

Background

Implementation of national development which simultaneously develops the environment, it is necessary to pay attention to the management and processing of renewable natural resources. With the preservation of natural resources such as forests, soil, water and sea as well as natural biological resources, these natural resources remain intact for SUSTAINABLE use, not only for the present generation but also for future generations. Therefore, natural resources must be utilized in such a way that their sustainability is guaranteed.

The forest area in Indonesia, which is estimated at 143 million hectares, is spread over ± 13,000 islands, both large and small islands. This forest is composed of approximately 4000 species of plants. However, only 267 species are classified as commercial timber-producing plants, 133 species are lesser known, while 90% are still unknown plants. This fact is supported by the collection conducted by the Forest Research and Development Center in Bogor. In that place, 3667 species belonging to 675 genera from 119 families have been collected (Anon., 2018).

Forests as one of the natural resources can produce economic objects that are human needs. One example of such economic object is the raw material for the timber industry. Thus natural resources in the form of forests can be used as a source of funds for Indonesia's development.

The need for development funds at home and the increasing demand for timber abroad has resulted in an increase in timber production and exports. However, prior to 1980 most of the production and export of wood (approximately 90%) was in the form of logs, while in the form of processed wood it was only relatively small. This condition is of course detrimental to the interests of the state. This can be seen from the 4 gatras. First, the export of logs deprives the country of opportunities to obtain the necessary jobs in wood processing. Second, the export of logs removes additional foreign exchange in the form of added value arising from the wood processing industry. Third, losing the opportunity to transfer technology in the wood industry. Fourth, log exports will further accelerate the depletion of forest resources (Soenardi), Realizing that these losses exist, the government is making various efforts to limit log exports and spur processed wood exports. It seems that this effort was successful after the promulgation of a Joint Decree of the Three Ministers in 1980. This was proven by the explosion in the wood processing industry, especially dominated by the plywood industry. Prior to 1980 there were only 29 plywood factories in production. After that year, the number of plywood factories increased rapidly, reaching a total of 110 in 1988 (Soenardi, 2018).

Sustainability of the production of such a number of plywood factories definitely requires raw materials in large quantities and continuously. In the next few years, it is estimated that the need for raw materials will reach 90 million m3. At that time, it is estimated that the existing natural forests will no longer be able to meet the increasing demand for timber. Therefore, the government has taken steps to develop Industrial Plantation Forests. The development of Industrial Plantation Forests is targeted to reach 4.4 million hectares in the next 15-20 years. Together with the existing plantation forests of 1.8 million hectares, the total area will reach 6.2 million hectares. Such a large plantation forest area will in time be able to supply the expected 90 million m3 of wood (Soenardi, 2018).

The role of selecting the species to be planted is very decisive in the development of Industrial Plantation Forests. The selected plant species must meet several criteria, including having high economic value, easy to plant, suitable for the place where it grows, has a high increment, has a short cycle, is more resistant to pests and diseases and has wood quality (characteristics) that meets requirements as a raw material for the wood industry (Apandi, 2018; Djamaluddin, 2018 and Subardjo, 2018). In this regard, Pterygota indica trees that grow in Indonesia may be recommended as a type of fiber wood (pulp). This is due to the good nature attached to Pterygota indica. These good properties include: this plant has fast growth, can grow on rather fertile laterite soils and nutrient-poor lime soils, resistant to pests and diseases and branch-free stems can be said to be Juras (Fundter and Wisse, 2018). In addition, the quality requirements (characteristics) of the selected wood must also meet the requirements as a raw material for the wood industry.

The natural resource in the form of forest needs to be endeavored to diversify the use of the types of wood. In addition to the types of wood that have been traded, the utilization of this species can extend to other types of wood, both those that are less well known and those that are not yet known.

One of the types of plants that can support Industrial Plantation Forests, Pterygota indica is still poor in information about the characteristics concerned with the field of Forest Product Technology. This fact has the possibility that in the future the Pterygota indica plant may be suggested as a raw material supplier for paper making, given the whitish color of the wood. Given that its use in Indonesia is limited as firewood or charcoal, the method of using it as a raw material for paper will increase the economic value of Pterygota indica. To be able to determine a type of wood for its proper utilization as a raw material for paper, there are several wood properties that need to be known, including some anatomical properties, specific gravity and some chemical properties.

The anatomical properties examined in this study included fiber length, fiber diameter, fiber wall thickness and lumen diameter. In addition, the percentage of vessel cells, radius cells, fiber cells and parenchyma cells. Research on chemical properties included extractive content soluble in cold water, extractive content soluble in hot water, extractive content soluble in alcohol-benzene, holocellulose, alpha cellulose, pentose, lignin and ash; wood physics research on specific gravity.

Aim

This research aims to:

1. Knowing the structure of Pterygota indica wood which includes the anatomical arrangement and fiber dimensions from the base to the tip of the tree in one tree.
2. Knowing the properties of Pterygota indica wood which includes several chemical properties and specific gravity, from the base to the tip of the tree in one tree.
3. On the basis of 1 and 2, it is hoped that the suitability of this type of Pterygota indica wood

for its use, especially as a fiber (pulp) material, can be determined.

Materials And Methods

Ingredient

The wood as a material in this study was obtained from the Faculty's ArboretumForestryGadjah Mada University in Yogyakarta.In addition, materials such as films, photographs, paraffin are also used. distilled water and chemicals eg perhydrol. Sodium hydroxide and Furfural phloroglucinol. Some of these materials were purchased at a chemical supply store and some were obtained from the Forest Product Technology laboratory, Faculty of Forestry, Gadjah Mada University in Yogyakarta.

Tool

The tools used in this studysaw blades, drying kilns, analytical balances, 40–60 mesh screens, sanding machines, microscopes, fibroscopes, photographic equipment, kurvinsters, electric cookers, measuring cups, erlenmeyer flasks and distillation coolers.

Research procedure

Selection of trees

One of several Pterygota indica trees that grow in the Arboretum I of the Faculty of Forestry, Gadjah Mada University, Yogyakarta, was chosen. The selected trees are in good health.

Felling of trees

Be measuredtallbuttress roots of Pterygota indica trees and the height of buttress roots is 92 cm above the ground. Then logging was carried out at a height of 92 cm above the ground level. After it fell, the tree was measured for its height, diameter and thickness of the bark.

The division of stem height

The tree trunk is divided into 5 parts in the direction of the long axis of the tree, in such a way that each piece has the same length. Each successive cut from the position of the base to the tip of the stem is coded A, B, C, D, and E, as shown in Figure 1 below.

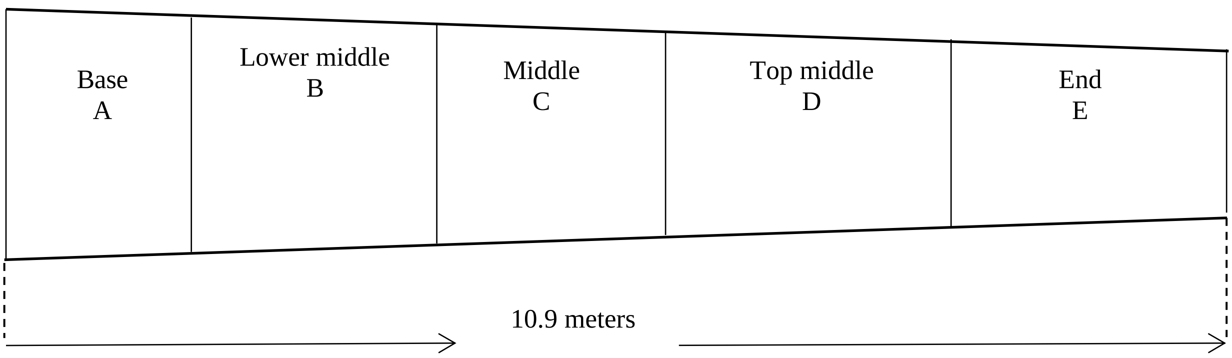


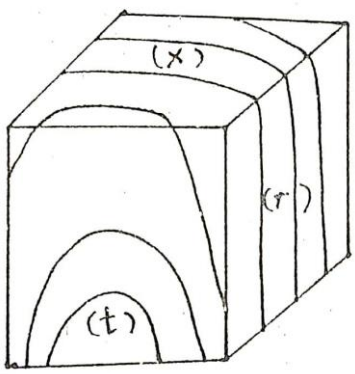
Figure 1 - The division of Pterygota indica wood pieces from the base position to the end of the tree

Sampling test

From each piece of stem, a disc 10 cm thick is taken. This takedonein the middle of the long axis of the tree. From this 10 cm long piece, test samples were made. Then 8 fruits were taken randomly to be examined.

Research implementation

Examplewood for the preparation of microscopic slides and maceration slides were taken from the same sample. For this purpose, wood samples are made in three orientation planes, namely the latitude (x), radial (r) and tangential (t) planes. For details, it can be seen in Figure 2 below.



Information:
x : transverse
r : radials
t : tangential

Figure 2 - Preparation of test samples for microscopic slides.

Study of wood anatomy

The test samples were in the form of small pieces of wood (sticks) with a size of 3 cm x 0.75 cm x 0.75 cm (length x width x height) from each treatment which were taken randomly from all parts of the wood. The pieces of wood were sliced with a microtome in cross section, radial section and tangential section with a slice thickness of 10–20 microns. From the wood slices obtained, preparations are made. After that, the preparations were photographed using a microscope photo with a magnification of 125 times. Anatomical photos in cross-sections obtained were then cut according to the cell type and weighed for each. The percentage of these cell types was calculated based on the ratio of the weight of the photo paper for each cell type (vessels, fibers, fingers and parenchyma) to the weight of one photo sheet (expressed in percent).

Research on fiber dimensions

Test sampleshapedsmall pieces of wood (sticks) with a size of 20 mm x 1 mm x 1 mm (length x width x height) taken from each piece of wood at random. The pieces of wood are put into a test tube containing a mixture of one part glacial acetic acid and 20 parts perhydrol (1:20). The test tube is then boiled in water at 100 C for 3–5 hours until a white test sample is obtained. The test sample in the test tube is then washed and filtered repeatedly. Washing using distilled water until the test sample is free from chemicals (acids). To obtain fiber, the clean test sample is shaken and dyed (safranin). The fibers obtained were then taken with a pipette placed on top of the object glass and covered with a cover glass and ready to be measured.

Measurement fiber length, fiber diameter, lumen diameter and cell wall thickness were determined in the following way:

a. Fiber length

Fiber length was measured on maceration preparations using a magnification fibroscope 50 times and measured with a curvimeter (which has been corrected for the ratio of the scale between 1 cm in the object and the scale in the curvimeter). Fiber length measurements were carried out 40 times for each test sample. The number of fibers measured is determined based on the results of preliminary measurements of 100 fibers. Fiber length data (in mm) obtained is then calculated by the formula:

$$N = \frac{4S^2}{L^2}$$

Where:

$$S^2 = \frac{\sum_{fiXi} 2 - \frac{\sum_{fiXi} 2}{n}}{n-1}$$

$$L = \frac{\sum fiXi}{n} x\ 0{,}05$$

Information.

N: measured fiber count.

S: standard deviation.

L: the average value of fiber length times 0.05. (5% error is considered sufficient).

Xi: fiber length.

fi: fiber frequency.

n: the number of fibers measured in the preliminary measurement (100 pieces of fiber).

With measurement As many as 40 of these obtained an average fiber length with an accuracy of 95%. Measurement repetitions were set 8 times.

b. Fiber diameter. lumen diameter and fiber wall thickness

Fiber diameter and lumen diameter were measured directly on the maceration preparation under a microscope (which is equipped with an objective scale and the scale has been corrected) with a magnification of 500 times. Measurements for each test sample are also determined by 40 fibers

Measurement of cell wall thickness was not carried out directly, but through the relationship between the difference in fiber diameter and lumen diameter divided by two (in microns).

The implementation of this research uses a modified method from the Forest Product Laboratory (in Silitonga et al. 2019).

DalIn this research also calculated the value of fiber dimension derivatives. The calculation is carried out by the formula:

$$1. Bilangan\ Runkel\ = \frac{2W}{I}$$

$$2. Bilangan\ Muhlsteph = \frac{d^2\ - I^2}{d^2}$$

$$3. Daya\ Tenun = \frac{L}{d}$$

$$4. Koefisien\ Kekakuan = \frac{w}{d}$$

$$5. Nilai\ fleksibilitas = \frac{I}{d}$$

Information:

W: cell wall thickness

d: fiber diameter

L: length, weight.

I : lumen diameter

Research on the physical properties of wood

a. Wood density

The test sample was made with a size of 5 cm x 2.5 cm x 2.5 cm, taken randomly from each wood. The test samples obtained were then immersed in distilled water for 3 days to achieve saturation conditions. The volume of the test sample was measured by placing it in distilled water. The difference in the weight of the sir after adding the ul sample and before that is the wet volume. The test sample (Vb= in cm3). After that the test samples were allowed to air dry for several days. Then the test samples were dried in a drying kiln at a temperature of 100–105°C. This drying is carried out continuously until it reaches a constant weight. This constant gui sample weight is defined as the furnace dry weight (B0= in grams): Measure the volume of the sample in the furnace dry condition by placing it in distilled water.Implementationresearch using British Standards guidelines 373.Specific gravity is calculated using the formula:

$$BD = \frac{Bo}{Vb} \quad \text{according to wet volume}$$

$$BD = \frac{Bo}{Vo} \quad menurut\ volume\ kering\ tanur$$

Research on the content of wood chemical components

Materials for research on the content of chemical components of wood are taken from the remaining wood aftermadesample research test on the anatomy and physical properties of wood The sample wood is cut into small pieces (chips), then cut into pieces the size of sticks to be ground into wood powder. This powder is filtered (sifted) with a 40–60 mesh sieve. This powder is then stored in closed bottles so that the water content of this powder is evenly distributed. Then the water content is calculated.

a. The extractive content is soluble in cold water

Provided are 2 units of sawdust ± 2 grams each. Put the sawdust inglass 400 ml cup and filled with 300 ml of distilled water. This mixture was left for 48 hours at room temperature with each stirring. Transfer the mixture into a filter cup whose weight is known. Washed with cold distilled water and dried to constant weight. The levels of extractive substances in cold water were calculated based on the reduced weight of sawdust. This lost weight is expressed as the weight of the cold water-soluble extractive using the following formula:

$$Extr\ rate. = \frac{bextractive\ weight}{powder\ weight\ in\ kiln\ dry\ condition} x\ 100\%$$

b. The extractive content is soluble in hot water

Provided 2 units of sawdust ± 2 grams each. The sawdust was digested with 100 ml of distilled water into a 300 ml Erlenmeyer flask which wasequippedby standing cooling and heating in a water bath whose level can be adjusted to remain higher than the surface of the solution in the cup. After heating for 3 hours, the contents of the cup are transferred to a filter cup whose weight is known, washed with hot water and in the furnace until the weight is constant. The reduced weight of the powder is calculated and expressed in terms of soluble content in hot water as a percent of the dry weight of the furnace or the initial weight of sawdust. - initially that is free of water (kiln dry) (W1) minus the furnace dry weight of extracted powder (W2) divided by the weight of the original sawdust which is free of water (furnace dry) multiplied by 100%.

$$Formula: \frac{W1 - W2}{W1} X100\%$$

c. Extractive levels are soluble in alcohol-benzene

provided 2 units of sawdust weighing ± 2 grams each in a filter cup. The cup is inserted into the soxhlet device and the end of the filter cup is arranged higher than the tip of the siphon, but the powder surface is lower. The cup is covered with a fine piece of metal sieve, so that no sample is lost. Extraction was carried out with 200 ml of alcohol-benzene with a ratio of 95% alcohol : benzene = 1 : 2 for 4–6 hours. Heating is regulated so that the velocity of exit and entry of the solvent into the filter cup is the same. The cup is removed from the socket and sucked until the contents are dry and washed repeatedly filling the cup with alcohol and then suctioned. After that, it is dried at 100–105°C until the weight is constant. Calculate the reduced weight of the powder. This lost weight is expressed as the weight of the alcohol-benzene soluble extractive. There are two ways to find the solubility in alcohol-benzene:

(a) by finding the weight of the powder as in (a) and (b).
(b) by finding the weight of the extractive in the extractive flask. This is done by evaporating the solvent, then drying the flask for 1 hour at 105°C or with the formula:

$$\frac{W2}{W1.P} x\ 100\%$$

where:

W1 = initial powder weight.
W2 = furnace dry weight of extracted powder.
P = Proportion of water-free wood in air-dried specimen:

$$\frac{100}{100 + \ water\ content}$$

d. Determination of holocellulose content

Weigh 0.7 grams of air-dried sawdust which is free of extractives and put it in a 250 ml Erlenmeyer bottle. Into the bottle, 10 ml of solution A is also put in, then 1 ml of solution B. The administration is carried out with a pipette. The bottle was closed with a rubber stopper and placed in a water bath at 70°C ± 2°C. The bottle was shaken every 0.5 hours. After heating for 0.75 hours, 1 ml of solution B was put into the bottle followed by shaking the bottle, repeated twice, each time the heating had lasted for 4 hours, the bottle was taken out and put in an ice water bath. Into the bottle was put another 15 ml of distilled water. The entire contents of the bottle is transferred to a filter cup whose weight is known. Wash the remaining contents of the bottle with 100 ml of 1% acetic acid solution and pour it into a filter cup, then suck it with a suction pump. Pour in 5 ml of acetone and wait until all the acetone drips out of the onwan filter. Ingi sucked the filter cup with a suction pump for 3 minutes, then left it for 4 days to reach air-dry moisture content. The filter cup was weighed and then the holocellulose content was determined according to the oven method. The holocellulose content was calculated. The samples were not discarded, but were kept for the determination of alpha cellulose content. Then allowed to stand for 4 days to reach wind-dry moisture content. The filter cup was weighed and then the holocellulose content was determined according to the oven method. The holocellulose content was calculated. The samples were not discarded, but were kept for the determination of alpha cellulose content. then allowed to stand for 4 days to reach wind-dry moisture content. The filter cup was weighed and then the holocellulose content was determined according to the oven method. The holocellulose content was calculated. The samples were not discarded, but were kept for the determination of alpha cellulose content.

Solution A is a solution consisting of glacial acetic acid, NaOH and distilled water with a ratio of 60 ml, 20 grams and 1 liter, respectively. Solution B is asolutionconsisting of $NaClO_2$ and distilled water with a ratio of 200 g and 1 liter, respectively.The implementation of this research uses the ASTM D 1103-60 method (Anon, 2019).

e. Determination of alpha cellulose content

Solution17.5% NaOH was added as much as 3 ml into the caring cup containing the holocellulose produced in advance. The filter cup is placed into a watch glass filled with distilled water so that the filter cup is submerged 1 cm. The holocellulose was stirred using a glass stirrer for 1 minute so that all of the holocellulose was wetted by 17.5% NaOH solution. After 5 minutes, another 3 ml of 17.5% NaOH solution was added while stirring again for 1 minute. After 35 minutes, 6 ml of distilled water was added. The filter cup is removed from the watch glass, and the filter cup is sucked in with a suction pump while pouring! 60 ml of distilled water. 10 ml of 10% acetic acid solution was added and followed by stirring using a glass stirrer. The filter cup is sucked with a suction pump while 80 ml of distilled water is poured. Pour 10 ml of acetone into the filter cup, wait until all the acetone drips out of the filter cup. The filter cup is dried in a drying furnace to a constant weight. Alpha cellulose content is calculated by the formula:

$$Cellulose\ alpha\ content = \frac{alpha\ cellulose\ weight}{weight\ of\ kiln\ dry\ wood} x100\%$$

Implementationthis study used the ASTM D 1103–60 method/guideline (Anon, 2019).

f. Determination of pentose content

Determination of pentose content was carried out using the ASTM D 1106–56 guideline method (Anon, 2019).Weigh 1.5 grams of sawdust into a 300 ml distillation flask. Put a piece of paraffin to prevent foaming and some poreus stuff top revent evaporation. Added 100 ml of 12% HCl by connecting it to a cooler (condenser). Heat the flask in such a way that the distillation takes place at the rate of 30 ml every 10 minutes. The distillate must be passed through filter paper before entering the measuring cup. After collecting 30 ml of distillate, another 30 ml of 12% HCl was added while washing the particles adhering to the flask, until the distillate accommodated 360 ml. The entire distillate was gradually added to 40 ml of a new solution of phloroglucinol-HCl which had been filtered while stirring (11 grams of phloroglucinol in 1500 ml of 12% HCl), so that the distillate would turn black-green. For 16 hours the distillate is left to stand, the black precipitate from the furfural phloro gluside will gather at the bottom of the measuring cup. The liquid is checked with aniline acetate paper. If it gives a pink color, it means that the precipitation is incomplete, therefore, another amount of phloroglucinol-HCl solution is added and allowed to stand for another 16 hours. The precipitate was collected and added to 100 ml of distilled water, dried in a furnace for ±2.5 hours at 100–105 °C. The result is furfural phloro gluside. The pentose weight calculation is:

Pentoses = (a + 0.0052) f

where:

a = furfural phloro gluside weight in grams.

b =0.895 kalnu a less than 0.03 grams.

0.887 if a is between 0.03–0.3 grams,

0.882 if & greater than 0.3 grams.

The pentose weight was calculated as a percent of the kiln dry weight.

g. Determination of lignin content

Determination of lignin content was carried out using ASTM D guidelines/methods1108-58 (Anon, 2019).Wood powder that has been extracted, weighed 1 gram. The extracted sawdust was transferred into a 1000 ml beaker and digested with 400 ml of hot water over a water bath (100°C) for 3 hours. The powder was filtered with a filter cup and the powder was allowed to air dry, then transferred to a small beaker covered with a watch glass. Slowly, while stirring, 115 ml of cold (12–15°C) 73% H_2SO_4 is added. The sawdust is stirred for at least 1 minute so that it is thoroughly mixed and allowed to stand for 2 hours after each stirring while the temperature is kept at around 18–20°C (the outer beaker is cooled to reach this temperature). The sawdust was washed in an Erlenmeyer glass of 1 liter, diluted to 3% acid concentration by adding 560 ml of distilled water. The powder in this glass is boiled under a vertical cooler for 4 hours, trying to keep the volume constant by adding hot water from time to time. After the insoluble materials are allowed to settle, they are filtered with a filter cup, washed with hot water until free from acid. The powder is dried in a furnace at 105°C until the weight is constant, cooled and then weighed. Lignin content is calculated as a percentage of the dry weight of the wood kiln before extraction.

Analysis of Results

Data regarding the anatomical arrangement, fiber dimensions, physical properties including fresh water content, wood specific gravity and wood chemical components, are calculated according to the applicable formulas. Results calculation. The obtained data is the result of research on the structure and properties of Pterygota indica wood. Analysis of the results of the study was carried out by statistical analysis (analysis of variance) for one variable that differed in the location of the wood parts (base, middle and ends) in 8 repetitions.

To find out more about the influence of factors that show significant differences in the analysis of variance, tests were carried out with Least Significant Difference (LSD) and graphical representations.

Results And Discussion

Treatise on Hevea *brasiliensis* This study gave the result that this wood was already known by the trade world. Therefore, there is no standard trade name for this wood. The scientific name of this log as mentioned above is Havea. Circle the year the type of log is not so clearly visible. The sapwood and heartwood are difficult to distinguish, as are early and late wood.

The structure of this log has vessels with single and double radial distribution, there is a yellowish white precipitate. Parenchyma has vasicentric type, metatracheal and aliform type to a small extent. The paratracheal parenchyma is often misshapen and the apotracheal parenchyma is straight and wavy. The radius of the wood is easy to see in sections (x), (t) and (r). There were no sap or resin channels found on the fingers. These fingers are multiseriate and there are sheath cells or sheath cells. This wood has an integrated fiber. The color of this wood is yellowish white and does not have a distinctive odor; belongs to wood which is rather heavy, slightly shiny in fresh condition and gradually becomes dull in line with the decrease in water content; is a medium strength wood; The touch effect on the surface is classified as moderate. The wood is easily attacked by blue mold (blue stain).

Timber Structure

Wooden structure *Pterygota indica* studied include wood anatomy and wood fiber dimensions. The properties of wood include physical properties and chemical components.

Anatomy of wood

Results study the average percentage of wood elements according to the location of the wood parts can be seen in Table 1 below

Table 1. Average percentage of the anatomical structure of Pterygota indica wood.

Wood element	Lay out the wood					
	A	B	C	D	E	Average
vessels	8.01	8.76	11.97	9,10	9.05	9,38
Fiber	60,66	60,87	60,32	66,60	55,64	60,82
Parenchyma	11.76	9.50	9,72	8.35	10,15	9.89
Fingers	27,57	20.86	17.97	15.93	16,15	19.69

Information:
A = Part of base wood
B = The lower middle part of the wood
C= The middle part of the wood
D= Upper middle part of wood
E = end of wood

Table 1 the showed that in general Pterygota indica wood was dominated by fibers, followed successively by radii, parenchyma and vessels. Observation of the effect of position along the stem shows that each element has a different tendency. The percentage of vessels increased from the base position to the middle position and then gradually decreased towards the stem tip. The percentage of fibers fluctuates from the position of the base towards the tip of the stem. The percentage of parenchyma and radius respectively decreased from the base position towards the stem tip, except at the most recent position (E position).

Table 1 shows that Pterygota indica wood has an average number of vessels of 9.38%, 60.82% of fiber and 29.30% of parenchyma (9.89% longitudinal parenchyma and 19.69% radius parenchyma).The percentage of Pterygota indica wood vessels can be said to be relatively low (a few) compared to other cells such as parenchyma, radii and fibers. These few vessel cells probably also have a high pulp yield. The percentage of vascular cells ranged from 8.01–9.05% for wood from the base to the tip of the tree. The higher it is on the tree trunk the greater the percentage of vascular cells and at a certain height it drops again to the tip but is still relatively high at the ends from the base.

The results of the research on the percentage of fiber cells (Table 1) ranged from 55.64–66.60% for wood from the base to the tip of the tree. The percentage of fiber cells is very large for Pterygota indica wood species and is very advantageous when used as pulp and paper material, because there are many good fibers as pulp and paper. Besides that, the percentage of Pterygota indica fibers is almost the same from the base to the tip of the tree, with increasing height on the tree trunk the percentage of fiber cells is getting bigger but at the end of the wood it is relatively decreasing.

The results of the study showed the percentage of longitudinal parenchyma cells (Table 1) ranged from 8.35–11.76% for wood from the base to the tip of the tree. The low percentage of parenchyma in relation to its content does not impair pulp processing nor impede drainage and processing machinery. In addition, with increasing location on the trunk, the percentage of longitudinal parenchyma cells tends to decrease. The results of this study are in accordance with the opinion of Soenardi (2018). The results of the radius cell studies (Table 1) ranged from 15.93–27.57% for wood from the base to the tip of the tree. The higher it is on the trunk, the smaller the percentage of radius cells but relatively larger at the ends than the wood at the bottom center.

The anatomical arrangement of the studied Pterygota indica wood gives the percentage of cell types that are not different from one another. Thus, the anatomy of Pterygota indica wood can be said to be uniform in all parts from the base to the tip of the tree. If the percentage of this anatomical structure is entered into the value of the Dadswell and Wardrop (2018) triangle, it will be somewhat at the top of the triangle. This means that it provides good information when used as pulp and paper material, because the data on the proportions of the anatomical structure when included in the Dadswell triangle is in the apex area slightly to the right. This structural uniformity of pulping is very advantageous because it will provide uniformity in the properties of the pulp.

Fiber dimensions

The results of the study of the dimensions of Pterygota indica wood fiber according to the location of the wood parts can be seen in Table 2 below.

Table 2. Average dimensions of Pterygota indica wood fiber.

Fiber dimensions	Lay out the wood					
	A	B	C	D	E	Average
Fiber length(mm)	1,531	1,627	1.075	1,922	1,822	1,721
Fiber diameter (micron)	14.79	19.69	23.08	31.80	31.99	24,27
Lumen diameter (microns)	9,15	12.81	15.68	29,49	30,86	23.58
Cell wall thickness (microns)	2.80	3,16	3.76	4,13	5,22	3.80

Information:
A = Part of base wood
B = The lower middle part of the wood
C= The middle part of the wood
D= Upper middle part of wood
E = end of wood

Table 2 shows that the values of fiber diameter and lumen diameter are increasing from the position of the base towards the tip of the rod. Likewise for fiber length and wall thickness. Exceptions are provided in section B for fiber length and in section D for wall thickness. Table 2 shows that the average dimension of Pterygota indica wood fiber is 1.721 mm; fiber diameter 23.58 microns; The lumen diameter is 16.09 microns and the cell wall thickness is 3.08 microns. With statistical analysis, the determined factors actually gave a difference according to the location of the wood part, but only the cell wall thickness showed no difference.

Judging from the length of the fiber (Table 2), the wood species of Pterygota indica have short fibers, because the average fiber length of the wood from the base to the tip of the tree is 1.721 mm, but for hardwood, the fiber is 1.721 mm long. Fiber length tends to increase from the base to the tip of the tree, but before reaching the tip of the tree it decreases. The results of this study are in accordance with Sanio's research (Bisset and Dadswell, 2018).

The results of fiber diameter measurements (Table 2) show medium-sized fiber diameters (cells), from the base to the tip of the tree measuring 14.97–31.99 microns (average 24.17 microns). The fiber diameter dimension tends to increase from the position of the base to the tip of the stem. The fiber diameter in the middle position was not significantly different from the fiber diameter in the other positions. The fiber diameter at the base position was not significantly different from the fiber diameter at the bottom center position and the middle position, but significantly different from the top center position and the end position. Likewise, the fiber diameter at the end position was not significantly different from the fiber diameter at the top center position and the middle position, but significantly different from the fiber diameter at the bottom center position and the start position.

The dimensions of the lumen diameter apparently have the same trend as the dimensions of the fiber wall thickness. This lumen diameter dimension also increases from the base position towards the top center then decreases to the end position. The lumen diameter dimension was not significantly different only with the base position, while the lumen diameter dimension at the bottom center position was not significantly different from the lumen diameter dimension at any position in the stem.

According to Table 2, the dimension of fiber wall thickness increases from the apex position towards the middle position. From the middle position the thickness of the fiber wall dimension slightly decreases to the top center position, then increases again so that it reaches the maximum dimension size at the end position.

Derived values of fiber dimensions

The test for the derived fiber dimension values which includes the Runkel number, Muhlsteph number, weaving power, stiffness number and fiber flexibility value, is presented in Table 3 below.

Table 3. Average runkel number, muhlsteph number, weaving power, stiffness coefficient, and the flexibility value of Pterygota indica wood fiber.

Lay out the wood	Runkel's number	Muhlsteph number (%)	Weaving Power	Stiffness Coefficient	Flexibility Value
A	0.484	53.97	54,253	0.163	0.672
B	0.885	79,40	57,664	0.234	0.530
C	0.849	69,10	60,420	0.229	0.540
D	0.539	36,91	68,097	0.296	0.627
E	0.656	47,66	64,555	0.228	0.603
Average	0.753	57,41	60,998	0.214	0.570

Information:
A = Part of base wood
B = The lower center of the wood
C = Middle wood section
D= Upper middle part of wood
E = End wood section

Table 3 is the easiest to conclude, namely the runkel number and the muhlsteph number, because the numbers can be related to the possibility of a wood being made into pulp and paper based on the fiber dimensions.According to the value of the Runkel number obtained from the comparison between 2 times the thickness of the cell wall (fiber) and the diameter of the lumen, the wood type Pterygota indica has fiber quality that is quite good for pulp, because it has an average Runkel number of 0.753. Thus, the maximum fiber quality category includes class III, namely because the Runkel number is above 0.50 and below 1.00. This means that this type of wood has a relatively thick cell wall and a relatively narrow lumen diameter. Thus, when this type of fiber is made of paper, it will produce sheets that are still quite flat (flattened) and provide a bond between the fibers that is still quite strong and good (Silitonga et al. 2019).

Judging from the value of the Muhlsteph number, which is a value obtained from the difference in the square of the diameter of the fiber and its lumen divided by the square of the diameter of the fiber (in percent), Pterygota indica wood is considered to have good fiber quality for pulp, because it has an average Muhlsteph number of 57, 41% or included in the class III fiber quality category, which is a class if the fiber has a Muhlsteph number between 30–80% (for wood materials). Thus, the fiber of this type of wood is plastic and when cooked it will produce paper with sheets that are quite smooth and even (Silitonga et al. 2019).

Judging from the woven power value of Pterygota indica wood fiber is quite high (average 60.998), it is sufficient to provide a smooth surface when making paper. From the stiffness coefficient value of Pterygota indica wood, the average is 0.211. A relatively small stiffness coefficient means that the type of fiber is not stiff, elastic and has a high folding strength, and conversely, a high coefficient of stiffness means that the fiber is not good for paper.

The average flexibility value of 0.570 can be said that this fiber is quite flexible, meaning that it can provide flexibility in terms of strength, especially breaking length strength. The higher the flexibility value means the better type of wood fiber to be used as pulp and paper material.

Properties of Wood

The properties of wood under review include those related to wood as a raw material for pulp and paper, especially the specific gravity and chemical components of wood.

Specific Gravity

The results of the study of the average specific gravity of Pterygota indica wood at various locations of the wood parts can be seen in Table 4 below.

Table 4. Specific gravity based on wet volume and dry volume of Pterygota indica wood kiln.

Specific gravity	Lay out the wood					
	A	B	C	D	E	Average
Wet volume	0.465	0.440	0.415	0.395	0.380	0.419
Furnace dry volume	0.510	0.506	0.500	0.499	0.4995	0.502

Information:
A = Part of base wood
B = The lower middle part of the wood
C= The middle part of the wood
D= Upper middle part of wood
E = end of wood

Table 4 shows that the average value of wood density based on wet volume is lower than that based on kiln dry volume. The specific gravity tends to decrease from the position of the base towards the tip of the stem, both of which are determined based on the wet volume and the dry volume of the kiln. From the base position to the direction From the tip of the rod it can be seen that the decrease in specific gravity according to soil volume is steeper than the decrease in specific gravity according to the dry volume of the kiln. The results of the research specific gravity (Table 4) ranged from 0.380–0.465 (average 0.419) for wet conditions and dry conditions of the furnace ranged from 0.495–0.510 (average 0.502). Judging from the numbers, Pterygota indica has a medium specific gravity.

In the fresh condition, the average water content of Pterygota indica wood is 108.69%, while in the wet condition, when it is measured for its specific gravity according to wet volume, it has an average moisture content of 48%. Table 4 shows that the highest specific gravity in both wet and dry conditions of the kiln is at the base of the tree. The higher the location of the tree trunk, the smaller the specific gravity. The results of this study are in accordance with Cockrell's research (Browning, 2019).

B According to the location of the wood parts after analysis, the close relationship between the types of wood shows a significant difference from one to the other. The difference tends to be seen between the ends or base of the wood, while the other parts are not different. If it is related to the thickness of the cell wall which also varies, then the direct support for the specific gravity is quite clear. because the value of the cell wall thickness also varies from the wood at the base to the tip. If related to extractives, this support is clearly visible with extractives in alcohol-benzene, whereas with extractives that dissolve in hot water and in cold water it is not clear, because it has a percentage that varies from the base to the tip of the tree. However, the decrease in specific gravity from the base to the tip of the stem in general can still be said to be correct if it is associated with the opinion of Brown et al. (2018).

Chemical components of wood

The results of the study of the chemical components of Pterygota indica wood according to the location of the wood parts can be seen in Table 5 below.

Table 5. Percentage of chemical components of Pterygota indica wood

Variable measured (%)	Lay out the wood					
	A	B	C	D	E	Average
Soluble extractive cold water	2.04	2,14	2.84	2.44	2.61	2,41
The extractive dissolves in hot water	3,19	3.70	3.73	3.63	3.57	3.58
Soluble extractive alcohol-benzene	6.03	5.97	5.93	5.86	5,26	5,81

holocellulose	77,80	76.98	75,48	75.55	74,34	76.03
Alpha cellulose	50,49	49.97	49.25	47,70	46,81	48,84
Pentosa	18,21	17.97	18,69	18,23	18.02	18,22
Lignin	19.35	19,18	19.06	18.98	18.87	19.09
Ash	0.61	0.54	0.50	0.41	0.52	0.52

Information:
A = Part of base wood
B = The lower center of the wood
C = Middle wood section
D= Upper middle part of wood
E = End wood section

Observation of the effect of position along the stem shows that each component has a different trend. The percentage of extractives soluble in cold water increased from the base position to the middle position, then gradually decreased towards the upper middle then increased again towards the stem tip. The percentage of extractive soluble in hot water increased from the base position to the middle position, then gradually decreased towards the stem tip. The percentage of alcohol-benzene soluble extractive decreased from the base position towards the tip of the stem. Likewise the alpha cellulose content, lignin content and ash content. The percentage of holocellulose decreased from the base position to the middle position, then increased again to the upper middle position, and then increased again towards the tip of the stem.

Judging from the value of the chemical component of Pterygota indica wood, the average percentage of extractives that dissolves in cold water is 2.41%, in hot water is 3.56% and in alcohol-benzene is 5.81%, the content of alpha cellulose is 48.84%, the morta content the average lignin is 19.09%.

From the figures for the content of these chemical components, the extractives are quite high, especially in alcohol-benzene. This may be due to the presence of deposits in the cells, especially in the form of tannins, fatty acids or dyes and essential oils that may be present.

In addition, the extractive content at the base to the tip of the tree can be said to be almost the same and does not make a real difference. It's just that there are differences in the content of soluble extractives in alcohol-bennen. With an analysis of variance, the difference is especially evident in the base wood, while towards the end the extractive content decreases slightly. The results of this study are in accordance with the opinion of Browning (2019).

According to Table 5, the Pterygota indica wood species has an alpha cellulose content of actually 48.84%. When viewed from the distribution of its content in the direction of the long axis of the tree, it can be seen that the alpha cellulose content decreases from the position of the base towards the tip of the stem. With a fairly high alpha cellulose content and almost the same for all parts of the wood, it means that Pterygota indica wood is quite good as pulp and paper material.

The results of the study showed that the lignin content (Table 5) averaged 19.09%, and was relatively moderate. When compared with lignin levels according to Soenardi (2019), Pterygota indica wood hasThe lignin content is relatively low, but when compared to Tsoumis (2020), the lignin content of Pterygota indica is moderate and tends to decrease from the base to the tip of the tree, but the decrease is relatively small.

Of all the chemical components studied, the chemical content of Pterygota indica is low to high with details of high cellulose content, relatively low lignin content and soluble extractive content: in cold and hot water (on average) moderate (Anon., 2018) and moderate alcohol-benzene soluble extractive levels (Soenardi, 2019 and Tsoumis, 2020). If this conclusion is related to its possibility as raw material for pulp, then Pterygota indica wood species can be said to meet the requirements.

Conclusions and Recommendations

Conclusion

From the results of research on the structure and properties of Pterygota indica wood as raw material for pulp by treating the wood from the base to the tip of the tree, the following conclusions can be drawn:

1. The average volume of Pterygota indica wood cells in percentage to the total wood volume. Anatomical structure: vessels 9.38%, fibers 60.82%, radii 19.69%, parenchyma (longitudinal) 9.89%.
2. The results showed that the average dimensions of Pterygota indica wood fiber produced: fiber length of 1.721 mm, fiber diameter of 23.58 microns, lumen diameter of 16.09 microns and cell wall (fiber) thickness of 3.80 microns.
3. The average results of some Pterygota indica wood properties show:

a. Specific gravity based on wet volume is 0.419 and 0.502 based on the dry volume of the kiln.

b. Chemical components: soluble extractive ingredients: 2.41% cold water, 3.56% hot water, 5.81% alcohol-benzene; 48.84% alpha cellulose content, 76.03% holocellulose content, 18.22% pentose content, 19.09% lignin content and 0.52% ash content.

4. According to its location in the wood from the base to the tip of the tree, the percentage of radii, specific gravity based on wet volume and dry volume, the percentage of alcohol-benzene soluble extractives, the percentage of holocellulose, the percentage of alpha cellulose and the percentage of lignin tend to decrease while for the wall thickness fiber, the fiber diameter tends to increase. For vessel presentation, fiber percentage, fiber length, lumen diameter, hot water-soluble extractives rose from the base to the top center then decreased again at the apex of the tree. Parenchyma percentage, cold water soluble extractive percentage, pentose percentage generally varies in Pterygota indica wood.

5. Fiber length, lumen diameter, specific gravity based on kiln dry volume showed differences in the wood from the base to the tip of the tree at a confidence level of 12. For fiber diameter, specific gravity based on wet volume, alcohol-benzene soluble extractives differed at the 5% test level while the percentage vessels, parenchyma percentage, radius percentage, fiber percentage, cell wall thickness, cold and hot water soluble extractives, alpha cellulose, holocellulose, pentose, ash and lignin percentages did not show significant differences from one part to another (base, middle and end).

6. With analysis of variance, at different positions in the direction of the long axis the tree will have: fiber length, lumen diameter which is very significantly different, fiber diameter is significantly different, while fiber wall thickness and the percentage of each wood element are not significantly different, specific gravity based on the dry volume of the kiln differed significantly, while the specific gravity based on the wet volume was significantly different: the extractive content in alcohol-benzene was significantly different while the extractive content in cold water, extractive content in hot water, alpha cellulose, holocellulose, pentose, lignin and ash were not real different.

7. The anatomical structure of Pterygota indica wood has a fairly large number of fiber cells (60.82% on average), vessels (9.38% on average and parenchyma (29.59% on average) consisting of 8.89% longitudinal parenchyma and parenchyma radius 19.69%) which is low. When placed in the triangle Dadswell and Wardrop (2018) the proportion of this anatomical structure is in the slightly apex area, so that Pterygota indica wood is good enough to be used as pulp and paper material.

8. From the results of measuring the dimensions of Pterygota indica wood fiber, it has short fibers, medium diameter and moderate cell wall thickness. In the derivative test, the Runkel number was 0.753, the Muhlsteph number was 57.411%, the weaving power was 60.998, the stiffness coefficient was 0.214 and the flexibility value was 0.570. From these figures, it means that Pterygota indica wood is quite good as a pulp material because it can produce flat sheets and provides a fairly strong and good fiber bond when paper is made which is quite smooth, flat and has a smooth surface, not stiff (elastic) and high paper strength.

9. From the results of research on specific gravity based on wet and dry volumes of the kiln, specific gravity can be categorized as medium class, so it is likely to be quite good if pulp and paper is used as raw material because it can provide a fairly high yield of pulp.

10. From the results of the chemical components of the studied wood, Pterygota indica wood species has a fairly high alpha cellulose content, relatively low lignin content and moderate extractive content. From the chemical research results, Pterygota indica wood is good enough for pulp and paper.

Suggestions

Some suggestions that need to be submitted in connection with the implementation of research and the results of this study are:

1. Further research is needed on the structure and properties of Pterygota indica wood with various ages and parts of its location, so that it can be found what age and location of the wood is the best for pulp and paper.

2. It is necessary to carry out research on the properties related to its use as construction wood on Pterygota indica wood at wind dry moisture content by applying treatments that can prevent fungal attack which is used as material for this research to determine precisely.

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